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CIRCULAR THINKING IN A TECHNOLOGICAL AGE: DESIGNING FOR A REGENERATIVE FUTURE

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Architecture, engineering, and construction sector is experiencing challenges related to environment and economic aspects. It consumes vast amounts of resources and energy and contributes heavily to global carbon emissions. Academics and industry leaders are trying to explore various strategies to combat climate change by shifting toward circularity. It is a systems-based approach that prioritizes regenerative design, responsible consumption, and closed-loop resource use. At the heart of this shift lies the interplay between circularity, technology, and the environment that can reshape how we live, produce, and consume. But this transformation is not simply about adopting greener practices; it's about rethinking the role of innovation in creating systems that can sustain our lives.

Circular economy (CE) is not just a sustainability trend; it is an emerging as a smart business model that balances environmental responsibility with sufficient profitability. It challenges businesses and cities alike to ask: how can we design products that are repairable, cities that are resource-aware, and systems that regenerate rather than deplete? Just as "brainware" is central to the success of smart cities, CE demands informed decision-makers, consumers, and designers who can navigate complexity and rethink waste as opportunity. By rethinking material flows and closing resource loops, CE offers a practical alternative to the outdated "take, make, dispose" mindset. Robust policy and legal frameworks for implementing the economic system by providing incentives and mitigating barriers are required to be issued by government, as well as business industries need to produce added value via eco-friendly products and services, and positive behaviors.

Technology that is combined with circular principles has the potential to accelerate our transition toward more sustainable living. Advanced technologies in the past years have make it easier for people to achieve towards circular transformation. For instance, Internet of Things allow us to give digital life to physical objects, tracking them from creation to disassembly. Artificial Intelligence can then analyze this information to find the best ways to repair, remanufacture, or recycle them. These tools are incredibly powerful, but they are just tools. They have no purpose or direction without human guidance. Their ultimate success depends entirely on how people choose to use them. Technology solutions can be used to integrate CE principles from the design to the operation stages. The technological revolution has made it possible to transform entire systems of production, management, and governance into more effective and efficient systems.

CE is not built by technology but a combination of different roles from the people. It is driven by human who think about a product's second and third life before it is even made. It is shaped by business leaders who have the courage to shift from selling disposable units to providing durable services. It is guided by policymakers who create rules that make it easier and more profitable to reuse materials than to discard them. And it is powered by a skilled workforce that can operate the advanced

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systems required for remanufacturing and recycling. CE and technology cannot function without the active participation of its citizens. By placing humanity at the core of this vision, we ensure that we are not just building a more efficient system, but a more resilient, equitable, and prosperous world.

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Urban Innovation, Sustainability, and Community Resilience

As urban environments grow increasingly complex, so does the challenge of designing policies, spaces, and systems that are inclusive, efficient, and resilient. In this issue, we present a collection of studies that reflect the diversity of urban issues across Southeast Asia and beyond, ranging from transport systems and green spaces to education, conservation, and infrastructure development. Each paper explores a different facet of urban life that offers insights collectively speak to broader themes of sustainability, governance, and community empowerment.

Langit et al. assess the acceptability of a proposed congestion charging system in the Central Business District (CBD) of Baguio City, Philippines. Employing an exploratory sequential design, the study uses key informant interviews and a perception survey to evaluate residents' attitudes. Findings indicate that the proposed scheme is slightly unacceptable due to factors like lack of information and perceived ineffectiveness, though revenue allocation may increase acceptance. The paper recommends transportation policy measures, including policy packaging, a pilot congestion charge, and public support building through information campaigns and transparency, to address traffic congestion in the CBD.

Yapjoco et al. examine the grassroots-led *Tanimang Bayan* initiative in Sitio San Roque, Quezon City, as an alternative model of urban agricultural extension during the COVID-19 pandemic. The study contributes to development and urban governance literature by showing how residents in informal settlements can act as both knowledge producers and extension agents, using participatory farming to promote food security and resist displacement.

Ty et al. profile physical activity usage in selected urban green spaces (UGS) in Marikina City, Philippines, using systematic observation and interviews. The study describes the historical background, facilities, and community use of Marikina River Park and Marikina Heights Park Complex. Findings reveal that most visitors engage in physical activity, with walking, biking, and dancing being common. The study also identifies the demographic distribution of park users. The paper concludes that UGS serve their intended purpose and recommends improvements to attract underrepresented groups and enhance physical activity participation.

Dere and Ojokunle analyze the impact of Nigerian seaports' operational performance on the construction sector's contribution to the Gross Domestic Product (GDP) from 2011 to 2023. Utilizing secondary data and regression analysis, the study identifies cargo throughput, personnel efficiency, and ship traffic as significant positive influences on GDP, while turnaround time and waiting time have negative effects. The research highlights the crucial role of port efficiency in driving economic growth and recommends investments in technology, workforce optimization, and policy interventions to improve port operations and support sustainable economic development.

Maestrecampo Jr. and Macahig present a case study of the "Start 'em Young Advocacy" program at Silliman University, Philippines, which engages students in community work with daycare centers. Employing Kolb's Experiential Learning Theory, the study examines student reflections using the "Head, Heart, and Feet" model to assess learning outcomes. The findings indicate that participation in the program fosters knowledge and skill development, shifts in attitude and emotion, and future planning. The paper argues for the value of urban environments as active learning spaces that support student development and contribute to the United Nations Sustainable Development Goals (UN SDGs).

Castro et al. explore the use of participatory exhibitions as an awareness-raising platform for bird window collisions, focusing on the work of Bird Window Strike Philippines. The study utilizes a pop-up exhibition with didactic and participatory elements to convey the problem and potential solutions. Visitor responses, including voting and comment cards, indicate a preference for window stickers and mesh as preventive measures and highlight emotional engagement with the issue. The paper demonstrates the effectiveness of exhibitions in raising awareness and gathering public perceptions on conservation concerns and recommends their use for co-creating biodiversity-inclusive cities.

Faremi and Arowolo investigate barriers to Construction 4.0 learning exposure among built-environment students in Nigerian tertiary institutions. The study contributes by identifying institutional, infrastructural, and curriculum-related challenges and recommends systemic reforms, such as curriculum redesign and improved infrastructure, to bridge the digital skills gap and enhance student preparedness for the evolving construction industry.

Nur'ain et al. develop a model for trip route planning to improve public transportation accessibility in Bengkalis City, Indonesia, using Geographic Information Systems (GIS). The research employs the Slovin sampling method and collects data through home interviews to create an origin-destination matrix. The study identifies areas with high travel demand and plans alternative routes, ultimately recommending one based on road conditions and alignment with activity centers. The paper highlights the importance of GIS in transportation planning and decision-making to enhance urban mobility.

Simanjuntak et al. investigate water risk reduction management through permaculture pedagogy, focusing on primary school students in North Sumatera, Indonesia. Findings reveal that engaging young participants in monitoring, managing, and communicating environmental issues promotes SDGs related to health, education, and environmental protection. The paper advocates for experience-based learning, community connection, and place-based authenticity to enhance environmental awareness and practical implications on permaculture principles.

We hope this edition may convey new insight and knowledge that benefit our readers. We welcome any comments or inquiries that you may have concerning the direction and the content of this journal. We invite you to join our venture by sending your work for future consideration.

Warmest regards from the Editorial Office,

Prof. Mohammed Ali Berawi
Editor-in-Chief

Perdana Miraj
Managing Editor

Dr. Mustika Sari
Managing Editor

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ACCEPTABILITY OF THE PROPOSED CONGESTION CHARGING SYSTEM IN THE CENTRAL BUSINESS DISTRICT OF BAGUIO CITY, PHILIPPINES

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ABSTRACT

The City Government of Baguio is proposing a congestion charging system in the Central Business District (CBD) to address the ongoing issue of traffic congestion in the city. Although it is an effective tool, low public acceptability hinders its implementation. This study aims to assess Baguio City residents' acceptability regarding the CBD's congestion charging system. Specifically, it seeks to (1) identify the factors that influence residents' acceptability of the proposed system, (2) evaluate whether there is a significant difference in acceptability across different road users (private vehicles, public transportation, cycling, and walking), and (3) provide recommendations for transportation policy planning in the CBD of Baguio City. The study employed an exploratory sequential design, using key informant interviews with four government officials and a perception survey involving 107 city residents. Survey results indicate that the proposed scheme is slightly unacceptable. Factors such as lack of information and awareness and perceived ineffectiveness reduce acceptability; however, revenue allocation may contribute to increased acceptance. Moreover, regardless of the mode of transportation, there is no significant difference in the level of acceptability or its influencing factors. Based on the low acceptability of the proposed system, the study recommends several transportation policy measures for the CBD of Baguio City: (1) policy packaging, (2) deployment of a pilot congestion charge, and (3) efforts to build public support through improved information and education campaigns, the establishment of information desks in barangays, and transparency in revenue allocation and management.

Keywords: Congestion charging; Demand management; Public acceptability; Traffic congestion; Transportation

1. INTRODUCTION

Traffic congestion is one of the major problems in urban areas worldwide. It increases travel times, affecting productivity and causing economic losses while producing more emissions, contributing to air pollution and human health problems (Afrin & Yodo, 2020; Lu et al., 2021). Rush-hour traffic may increase emissions by 14.3–30.4% for different pollutants and raise gasoline and diesel consumption by 24.3–26.8% and 19.6–22.0%, respectively (Wen et al., 2020).

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In London, traffic congestion increased travel time to 156 hours in 2022, costing USD 1,659 per driver (Zhang et al., 2023). Yet, the social aspects of externalities, including road safety, health impacts, and equity issues, are often overlooked in transport policy planning due to difficulties in measurement (Huang & Loo, 2022).

To address these issues, various countries have implemented measures to improve public transportation systems. Among the most widely adopted are policies promoting public and active transport, followed by regulatory measures, smart transport systems, and road capacity expansion (Huang & Loo, 2022; Verma et al., 2023). Travel demand management (TDM) is another strategy that seeks to meet people's travel needs by offering alternatives, reducing travel burdens, or redistributing travel demand. TDM can be categorized into soft strategies such as healthy travel promotion, shared mobility education, and community initiatives. In contrast, hard strategies refer to structural actions affecting the travel environment, including infrastructure improvement, higher vehicle usage costs, usage restrictions, financial incentives, and other planning measures (Wang et al., 2024). Another classification is the push and pull strategy. Push policies discourage car use by making it less attractive (e.g., fuel taxes, parking fees, cordon pricing), whereas pull policies promote non-car modes by improving their appeal (e.g., enhanced public transport, transit management, green vehicles) (Moeinaddini & Habibian, 2023). Push policies have effectively reduced traffic congestion, although they often face low public acceptability that limits their implementation (Moeinaddini & Habibian, 2024).

This study aims to analyze the public acceptability of the congestion charging system as a TDM push strategy in the case of Baguio City, Philippines. Specifically, this study aims to (1) identify the factors that influence the acceptability of Baguio City residents on the congestion charging system in the CBD, (2) evaluate the significant difference in the acceptability of different road users (private vehicles, public transportation, biking, and walking), and (3) provide recommendations on transportation policy planning in the CBD of Baguio City. The findings of this study serve as a basis for creating sounder and more effective strategies and policies to address traffic congestion problems in the Philippines and other countries for efficient transportation systems and more sustainable and liveable cities and communities.

2. LITERATURE STUDY

Congestion charging is a TDM push strategy that discourages private vehicle use by imposing fees on vehicles entering designated zones (Gomez, Dela Cruz, & Muhi, 2024). Studies have found that such schemes reduce road user costs by lowering fuel consumption, travel time opportunity costs, and accident rates while improving environmental quality and public health, particularly on heavily congested roads (Gomez, Dela Cruz, & Muhi, 2024). However, timely legislation and successful implementation of TDM policies are influenced by public acceptability (Marazi et al., 2022; Moeinaddini & Habibian, 2023).

Several studies have analyzed public acceptability of congestion charging systems in countries such as China (Liu, Lucas, & Marsden, 2021; Li et al., 2020; Zhang, Liu, & Zhang, 2023), Norway (Aasness & Odeck, 2023; Tvinnereim et al., 2020), Greece (Petraki et al., 2022), Switzerland (Baranzini, Carattini, & Tesauro, 2021), Indonesia (Sugiarto, Miwa, & Morikawa, 2020), India (Marazi et al., 2022), the United Arab Emirates (Abulibdeh, 2022), and Sweden (West & Börjesson, 2020). These studies found that levels of acceptability vary based on personal background, travel purpose, type of road user, willingness to pay, prior congestion experience, and other socio-demographic factors. Additional factors affecting acceptability include access to information, perceived effectiveness, prior knowledge of the scheme, and equity considerations.

Although congestion charging presents a promising TDM strategy to address traffic congestion, it has not yet been implemented in the Philippines. According to the Asian Development Bank (ADB), the country lost an estimated ₱3.5 billion per day due to traffic congestion in Metro Manila in 2017, with projections reaching ₱5.4 billion per day by 2035 if no interventions are introduced (ADB, 2023). Current TDM measures in many Philippine cities include color and number coding schemes, truck bans, "no parking, no car" policies, road widening, bypass roads, route rationalization, smart traffic management systems, and the modernization of public utility vehicles—replacing outdated jeepneys with electric or Euro-4 compliant vehicles (Agaton et al., 2020; Billones et al., 2021; Guno et al., 2021).

Meanwhile, Baguio City is planning to implement a congestion charging system as a pilot TDM initiative. This scheme proposes collecting fees from vehicles entering congested areas during peak hours to redistribute traffic and encourage public transport use. However, its implementation faces challenges related to public perception from residents and tourists.

While the public perception of congestion charging systems has been studied in other countries, Baguio City presents a unique case for the following reasons: (i) it is one of the most visited tourist destinations in the country, known as the "Summer Capital of the Philippines"; (ii) it serves as a key access point between the Cordillera and Ilocos regions; (iii) geographic constraints limit the city's ability to expand roads and parking infrastructure; and (iv) in 2023, the city government entered a joint venture with Metro Pacific Tollways Corporation for the planned implementation of the proposed congestion charging system.

3. METHODS

3.1. Research Local and Congestion Charging Zones

The proposed congestion charging system was analyzed using the case of the Central Business District (CBD) of Baguio City, located in the Province of Benguet. According to the Comprehensive Land Use Plan (2013–2023), the CBD is characterized by intense commercial activity—including banking and finance centers, malls, internet service centers, the public market, hotels, restaurants, small and micro enterprises, and tourist destinations—as well as institutional buildings such as private schools and universities, hospitals, and government offices, alongside residential areas. These diverse and concentrated activities have contributed to the persistent traffic congestion in the CBD.

One of the current travel demand managements (TDM) measures implemented in the area is City Ordinance No. 01, Series of 2003, or the Baguio City Number Coding Scheme. This ordinance prohibits any motor vehicle from entering or operating within the number coding zone from 7:00 AM to 7:00 PM, based on the last digit of the vehicle's license plate and the designated day of restriction. The detailed schedule of the vehicle prohibition scheme is presented in Table 1 below.

Table 1 Schedule of Prohibition from Operation of Motor Vehicles

Number Code	Day Prohibited
1 – 2	Monday
3 – 4	Tuesday
5 – 6	Wednesday
7 – 8	Thursday
9 – 0	Friday

Additionally, City Ordinance No. 05, Series of 2017, titled *"Regulating the Use of Streets in the City of Baguio by Heavy Equipment Vehicles, Trailers, Dump Trucks, and Other Freight Trucks,"* prohibits such vehicles from traveling within the CBD from 6:00 AM to 9:00 PM. Other strategies for managing traffic congestion in the city include the implementation of one-way traffic and re-routing schemes. These measures are typically enforced during holidays and peak tourist seasons. The designated entry zones for the proposed congestion charging scheme in the CBD are illustrated in Figure 1 below.

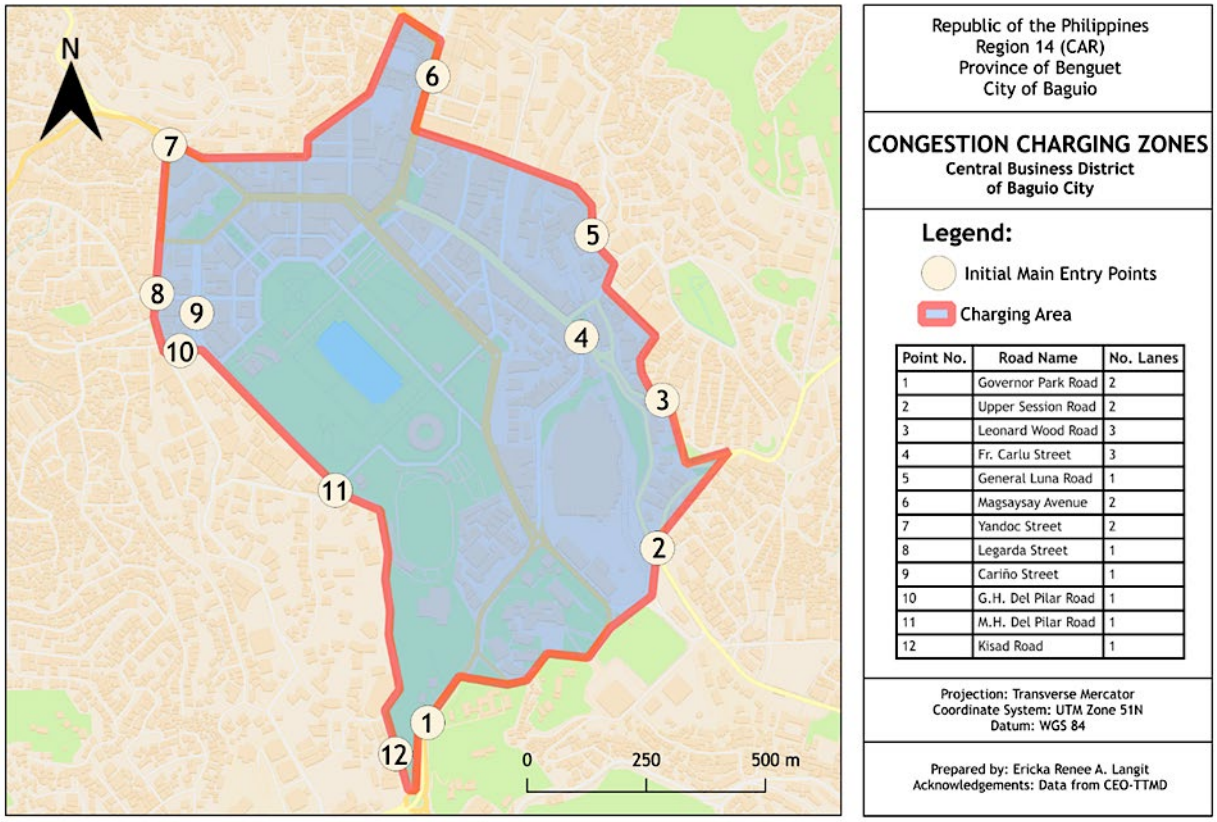

Figure 1 Figure 1 Congestion Charging Entry Zones Map
(Adapted from CEO-TTMD)

According to the City Engineering Office – Traffic and Transportation Management Division (CEO-TTMD), the degree of traffic congestion is evaluated alongside the existing measures when considering the implementation of the proposed congestion charging system. However, if the re-routing and one-way traffic schemes and city ordinances (number coding scheme and truck ban) remain ineffective, the proposed congestion charging system is viewed as a more viable solution to reduce vehicle volume, particularly within the CBD. The congestion charging entry zones map, presented in Figure 1, shows the proposed toll collection points located at the primary entry routes and highlights the designated charging area.

3.2. Research Design

This study utilized a mixed methods design, combining elements of qualitative and quantitative research approaches. Specifically, an exploratory sequential design was adopted. Qualitative data were collected first, and the analysis results were used to develop the quantitative instrument further to examine the research problem (Toyon, 2021). In-depth interviews with local government offices were conducted to gather information on the transportation issues and the proposed congestion charging system in the city.

The advantages of conducting expert interviews include (i) contributing to the understanding of micro-processes and decision-making practices, (ii) addressing broader questions that are not easily

examined through experimental or statistical methods, and (iii) providing data that link macro and micro levels of analysis (von Soest, 2023). Expert interviews also provide a more accurate description of the reality surrounding the subject being studied (Langit et al., 2024). The factors identified from the interviews were incorporated into the survey questionnaire to assess how they influence the acceptability of the congestion charging system in the CBD.

3.3. Data Collection, Research Instruments, and Study Participants

The participants for the key informant interviews (KII) were representatives from local government offices, specifically the City Engineering Office – Traffic and Transportation Management Division (CEO-TTMD), Baguio City Police Office – Traffic Enforcement Unit (BCPO-TEU), and the City Planning, Development, and Sustainability Office (CPDSO), as shown in Table 2. An interview guide was prepared to facilitate the data collection. The guide consisted of three sections: the first addressed traffic congestion, the second focused on the proposed congestion charging system, and the third explored the public acceptability of the proposed TDM strategy.

Table 2 Key Information per Local City Office

Office	Number of Informants	Participants
CEO-TTDM	2	TTMD Education Division Head TTMD Head
BCPO-TEU	1	BCPO-TEU Chief
CPDSO	1	Planning Officer
Total	4	

On the other hand, the survey questionnaire was adopted from the City Engineering Office's (2022) Study on the possibility of imposing a Traffic Congestion Fee in the Central Business District in Baguio City.

Table 3 Socio-demographic Profile of Respondents

Age	Income	Location/Residence	Mode of Transportation
<18, 6.5% 18-24, 44.9% 25-40, 28% 41-65, 20.6%	<Php 10k, 38.3% Php 11k-2k, 15% Php 21k-30k, 15.9% Php 31k-40k, 14% Php 41k-50k, 8.4% >Php 50,000, 8.4%	Irisan, 11.27% Camp 8, 10.28% Bakakeng, 6.54% Asin, 6.54% Balsigan, 3.74% Camp 7, 3.74% City Camp, Honeymooh-Holy Ghost, Kias, Loakan, Magsaysay, Pinsao, Teodora Alonzo, 2.80% Cabinet Hill, Dominican Hill, Guisad, New Lucban, Quezon Hill, Scout Barrio, Upper Quirino-Magsaysay, 1.87% Others, 0.93%	Private vehicle, 21.5% Public Transportation, 74.8% Walking, 3.7%

The instrument consisted of four sections: (1) informed consent; (2) socio-demographic profile of the respondent (age, monthly income, barangay of residence, and mode of transport to the CBD), with a list of major thoroughfares in the CBD included to assist respondents in identifying the area; (3) acceptability of the congestion charging system in the CBD, in which information was provided including a map of the charging zone and entry points, along with a brief description that vehicles

would be charged a fee for using designated roads during peak hours; and (4) an additional question directed to private vehicle users. The last two sections were operationalized using a four-point Likert scale.

The main respondents were residents of Baguio City, specifically users of different transportation modes traveling to the CBD, including private vehicle users, public transportation passengers, cyclists, and pedestrians. Convenience sampling was employed in distributing the questionnaire, which was administered online through Google Forms from December 28 to December 31, 2023. The survey received a total of 107 responses. The link was circulated via a public website (e.g., Facebook), and participation was based on accessibility and respondent willingness. The distribution of respondents by type of road user is presented in Table 3.

3.4. Data Analysis

Descriptive statistics were used to analyze the acceptability of the congestion charging system and the influencing factors. Specifically, percentage frequencies were computed to determine the proportion of each response per factor, and weighted means were used to assess the strength of opinions. On the other hand, a One-Way ANOVA (Analysis of Variance) was employed to examine significant differences across different modes of transport and related factors and attitudes. This method compares the means of two or more independent groups to determine whether the associated population means differ significantly using the F-test.

3.5. Ethical Considerations

This study adheres to the principle of the Declaration of Helsinki regarding research involving human participants. The interview guide and the survey questionnaire included an informed consent section to assure respondents that their participation was voluntary. Respondents were informed that they had the right to withdraw consent or discontinue participation without penalty or loss of benefits to which they would otherwise be entitled.

4. RESULTS AND DISCUSSION

In general, the acceptability of the residents of Baguio City regarding the strategy was assessed through the question: "How acceptable would the congestion charging system be for you?" The weighted mean of the responses was 2.46, which falls under the interpretation of “slightly acceptable.” Similar to the findings in Taiwan (Ge et al., 2014), the likelihood of non-acceptance (i.e., very unlikely and unlikely to accept) is higher than acceptance. This reflects the low acceptability commonly associated with congestion charging in contexts where it has yet to be implemented. A similar level of low acceptability has been reported in other studies, such as those on Stockholm (43–52%), Gothenburg (33%), and the Netherlands (2.9 on a 7-point scale) (Börjesson, Eliasson, and Hamilton, 2015; Ma & He, 2020). The respondents' perceptions can be further explained through the identified influencing factors discussed in the following sections.

4.1. Factors of Public Acceptability to the Congestion Charging System

The KII findings identified several factors that may affect the public acceptability of a congestion charging system in Baguio City. These include (1) problem perception, (2) information and awareness of the congestion charging system, (3) perceived effectiveness, (4) revenue allocation and equity, and (5) attribution of responsibility. Addressing these factors can help the local government build public support for the strategy and advance its implementation.

4.1.1. Problem Perception

Residents were asked to assess eight transport-related issues and whether these were perceived as societal problems. They also evaluated whether the conditions of these issues were likely to improve

or deteriorate in the next five years. Table 4 presents the residents' evaluations, in which most transport-related issues were rated as very serious. Traffic congestion was most frequently identified as a very serious problem (M=3.64), followed by insufficient parking spaces (M=3.61) and the increasing use of private vehicles (M=3.34).

Table 4 Opinion about the Transport Problems in CBD and Perception in the Next 5 Years

Transport Problems*	Opinion on Current Problem			Perception in the Next 5 Years		
	Mean	SD	Interpretation	Mean	SD	Interpretation
Traffic Congestion	3.64	0.556	A very serious general problem	1.79	0.998	Getting bad
Limited Road Capacity	3.27	0.808	A very serious general problem	2.15	1.097	Getting bad
Not enough parking spaces	3.61	0.711	A very serious general problem	2.05	1.136	Getting bad
Inadequate public transport	2.84	0.881	A major general problem	2.43	1.150	Getting bad
Increased use of private vehicles	3.34	0.846	A very serious general problem	1.86	0.905	Getting bad
Disorderly loading/ unloading on streets	2.90	0.941	A major general problem	2.44	0.983	Getting bad
Air pollution	3.55	0.730	A very serious general problem	1.81	1.011	Getting bad
Noise pollution	3.21	0.880	A major general problem	2.04	1.009	Getting bad

Interpretations for the current problem: 3.26-4.00: a very serious general problem, 2.51-3.25: a major general problem, 1.76-2.50: a minor general problem, 1.00-1.75: not a general problem. Interpretations for perception: 3.26-4.00: getting better, 2.51-3.25: staying the same, 1.76-2.50: getting bad, 1.00-1.75: getting worse.

* Based on the TPTM Self-Assessment Survey (2008) and KII

Respondents also raised the lack of road infrastructure improvement, inadequate road safety measures, and ineffective public transport terminals. The congestion charging system primarily aims to address traffic congestion in the CBD. When asked, "Do you think there is a need to limit the amount of traffic in the CBD?" the weighted mean was 3.52, indicating strong agreement on the necessity of traffic limitation.

The results suggest that when traffic-related problems are considered serious and pressing, support for congestion charging becomes more likely (Milenković et al., 2019; Nilsson et al., 2016). However, some studies indicate that recognition of transport issues does not automatically translate to support for congestion charges (Liu et al., 2021; Hamilton et al., 2014). Other findings indicate that concern over environmental problems is more closely linked to support for such strategies (e.g., Börjesson et al., 2015; Hamilton et al., 2014; Ma & He, 2020). In this study, air pollution was considered both a serious problem and one expected to worsen. Despite this, the acceptability of the congestion charging system remains low.

4.1.2. Information and Awareness of the Congestion Charging System

Infromation regarding the congestion charging system was obtained from KII sessions with CEO-TTMD. To reduce congestion and vehicle numbers, the respondents were given basic information:

congestion fees would be charged to vehicles using specific roads during peak hours (day and afternoon). The explanation included only general details since the system is still under development.

Awareness of the system was assessed by asking: "Have you heard of the strategy before?" The weighted mean response was 1.59, indicating that most respondents had “heard nothing at all.” Among those with some awareness, social media (24.62%) and news sources (11.54%) were the most common channels. Table 5 presents additional sources of information.

Table 5 Source of Information and Awareness on Congestion Charging

Avenues	Frequency	Percentage
Information Education Campaign	7	5.38%
Public Consultation	5	3.85%
Social media	32	24.62%
News	15	11.54%
Radio	6	4.62%
N/A	65	50%

Liu et al Liu et al. (2021) identified a lack of information as a significant barrier to implementing a charging scheme in Edinburgh. This aligns with the low awareness among Baguio City residents. Abulibdeh (2020) emphasized that implemented schemes should highlight the rationale, benefits, and use of revenues to increase public understanding. Information presented in an understandable format could improve acceptability (Liu et al., 2021). In other cases, such as in Edinburgh and Hong Kong, limited communication resulted in minimal awareness of potential benefits (Gu et al., 2018).

Even in the face of initial opposition, greater familiarity with the scheme has been shown to increase public support (Milenković et al., 2019). Opposition tends to decline once benefits become more apparent and acceptance rises (Borjesson et al., 2015). Changes in acceptability over time have been documented, especially after implementation, when the system’s positive effects become visible (Börjesson et al., 2015; Krabbenborg et al., 2020; Romero et al., 2020).

4.1.3. Perceived Effectiveness

Before answering questions about perceived effectiveness, respondents were provided basic information about the congestion charging system. They were then asked, “How effective do you think this strategy will be in reducing the traffic in the CBD?” The average rating was 2.27, indicating that the strategy is perceived as “less effective” in reducing traffic volume.

Uncertainty or skepticism, particularly regarding the potential benefits, is often cited as a key reason for public opposition to congestion pricing (Gu et al., 2018; Hamilton et al., 2014). Ma and He (2020) reported that 56% of respondents viewed effectiveness as a critical factor behind resistance to congestion charges, believing that “congestion charges cannot solve the traffic congestion and air pollution problems.” Similarly, Sun et al. (2016) found that perceived effectiveness was not directly related to public acceptability. Their study highlighted the need for additional supporting measures, such as media outreach and full-scale trials, to improve acceptability regarding effectiveness.

Moreover, information and awareness about the congestion charging scheme are closely associated with perceived effectiveness. Borjesson et al. (2015) emphasized that uncertainty about the measure’s effectiveness could negatively influence its prospects. Thus, increased public communication and education efforts are necessary to build confidence in the strategy and improve its chances of successful implementation.

4.1.4. Revenue Allocation and Equity

Respondents were asked to indicate their preferred amount for the congestion fee. The majority (54.21%) preferred a fee between Php 5.00 and Php 30.00, followed by 21.50% who selected the next lowest bracket of Php 35.00 to Php 60.00. Table 6 presents the different congestion fee ranges.

Table 6 Congestion Fee Ranges

Congestion Fee*	Frequency	Percentage
Php 5.00-30.00	58	54.21%
Php 35.00-60.00	23	21.50%
Php 60.00-100.00	12	11.21%
Php 120.00-250.00	7	6.54%
Php 300.00-2,000.00	7	6.54%

* Adopted from CEO Study on the possibility of imposing Traffic Congestion Fee in the Central Business District in Baguio City (2023)

Respondents identified four main areas for revenue allocation: (1) supporting the general city budget, (2) improving traffic flow through measures such as road construction and signalization, (3) enhancing the quality of public transportation, and (4) upgrading facilities for pedestrians and cyclists. Additional suggestions were also categorized into the following:

a) incentives for transportation personnel and employment generation (e.g., assistance for public utility jeepney drivers, hiring of additional traffic enforcers, service incentives for public transport drivers, providing modern jeepneys rather than requiring drivers to purchase them, and funding for future modern jeepney programs);

b) environmental initiatives (e.g., tree planting, improved garbage disposal systems in the CBD using color-coded bins);

c) city planning and infrastructure (e.g., using funds for planning and implementation efforts, hiring consultants, increasing road capacity, housing development, and development of other areas in the CBD);

d) parking infrastructure development (e.g., creating additional parking spaces or facilities and integrating with environmental preservation efforts).

These proposed allocations align with previous studies, where revenue was used for non-motorized and motorized traffic improvements, investments in public transport, and enhanced infrastructure for pedestrians and cyclists (Milenković et al., 2019; Krabbenborg et al., 2020; Hamilton et al., 2014). While Baguio City residents expressed support for these redistributive measures, findings from Zhang, Liu, and Zhang (2023) suggest that such allocations have minimal impact on increasing public acceptance of congestion charging. This aligns with the current study's result, which shows a slightly unacceptable rating.

In terms of fee acceptability, results from this study are consistent with the CEO-TTMD survey, in which most respondents preferred a fee of Php 35.00 to Php 60.00. However, if this amount is adopted as the prevailing rate, it is unlikely to reduce traffic volumes significantly during peak hours. Consequently, the congestion charging system may be perceived more as a revenue-generating measure than an effective traffic management strategy.

This perception parallels the Polluter-Pays Principle, where users are willing to pay to compensate for the negative externalities caused by their actions (Corvino, 2023). However, in this case, respondents expect immediate compensation without fully resolving the underlying traffic problem.

4.1.5. Attribution of Responsibility

In identifying the perceived responsibility for resolving transport problems in the CBD, respondents attributed a "large responsibility" to external actors, primarily the City Government (M = 3.91). Internal attributions, labeled as "you" (referring to the respondents themselves), were rated as having "some responsibility" (M = 2.97), as shown in Table 7. Respondents also identified other external actors as responsible, including media, tourists, public utility drivers, and other local government units, such as barangays and their officials.

Table 7 Stakeholders Responsible for Transport Problems

Stakeholder	Mean	SD	Interpretation
Motorists	3.27	0.708	Large responsibility
City Government	3.91	0.292	Large responsibility
Business Community	3.26	0.731	Large responsibility
You	2.97	0.863	Some responsibility

Interpretations for responsibility: 3.26-4.00: large responsibility, 2.51-3.25: some responsibility, 1.76-2.50: little responsibility, 1.00-1.75: no responsibility.

For the respondents in Baguio City, the responsibility to address transport problems is largely seen as the duty of the City Government, with individuals acknowledging a limited role. This perspective reflects the broader trend in urban settings where central transport authorities are typically tasked with providing, operating, and maintaining public transit systems and regulating modes of transportation, many of which are managed by private entities (Abdel Wahed Ahmed & El Monem, 2020).

In the Philippine context, the complexity of improving urban transport systems is compounded by the decentralized ownership of public transport. Services are often operated by individuals, cooperatives, or companies rather than the state, complicating efforts to achieve more integrated and sustainable systems (Guno et al., 2022). According to Hrelja, Khan, and Pettersson (2020), efficient public transport is typically the result of dynamic interactions among public authorities at various levels, private operators, unions, and stakeholder groups.

In this regard, the media and civic organizations can also play a critical role. They may collectively advocate for reforms and pressure local governments to improve transport infrastructure and policies (Alm & Pulson, 2023).

4.2. Significant Difference in the Acceptability of Different Road Users on the Congestion Charging System in the CBD

Table 8 presents the results of the ANOVA. The findings show no significant difference in the acceptability of the congestion charging system among different road users. All groups share a similar level of acceptability, which in this case is interpreted as "slightly unacceptable."

Additionally, the factors of Information and Awareness, Perceived Effectiveness, and Revenue Allocation and Equity were examined. The results indicate no significant difference in the influence of these factors on the acceptability of the system across different road users: Information and Awareness [$F(2,104) = 0.551$, $p = 0.578$], Perceived Effectiveness [$F(2,104) = 1.446$, $p = 0.240$], and Revenue Allocation and Equity [$F(2,104) = 1.564$, $p = 0.571$].

Table 8 ANOVA Results on Acceptability of Different Road Users on Congestion Charging System and Influence of Determined Factors on the Congestion Charging System in the CBD

		One-way Anova	
		F	**Sig**
Acceptability		2.684	.073*
Factors			
Information and Awareness	Different road users (Private Vehicles, Public Transportation, Walk)	1.446	.240*
Perceived Effectiveness		0.564	.571*
Revenue Allocation and Equity		0.551	.578*

*Statistically significant differences at p<0.05 were examined.

These results are similar to the findings of Shatanawi et al. (2020), where perceptions of transport-related problems and internal attribution of responsibility (individual) contributed minimally to explaining resident acceptability. In contrast, studies by Abulibdeh (2020), Krabbenborg et al. (2020), Shatanawi et al. (2020), de Dios Ortúzar et al. (2021), Fall (2022), Marazi et al. (2022), and Zhang, Liu, & Zhang (2023) identified significant differences among road users, particularly between private vehicle users and commuters (public transport), regarding attitudinal factors. In these studies, non-car users were more likely to accept the implementation of congestion charges than car users.

4.3. Transportation Policy Planning Recommendations in the CBD of Baguio City

The following transportation policy planning measure are recommended based on the residents' acceptability.

4.3.1. Policy Packaging

The proposed congestion charging system cannot be fully implemented in Baguio City due to the absence of supporting ordinances, technology, and infrastructure. The system may be introduced as part of a comprehensive policy package to address these limitations. Policy packaging, a form of TDM strategy, combines a primary (effective) policy with auxiliary (acceptable) policies to improve overall policy effectiveness (Moeinaddini & Habibian, 2023). A review of prior TDM implementations shows that individual measures are insufficient when used alone; the combined application of push and pull strategies is more effective (Toan et al., 2023; Wang et al., 2022). In this case, the congestion charging system—classified as a push measure—could be more effective when combined with pull strategies such as improvements in public transportation and park-and-ride infrastructure.

Improvement of Public Transportation

It is expected that the use of public transportation will increase. However, its current capacity (i.e., ineffective public transport terminals and inadequate public transport vehicles) may not be sufficient to meet the increased demand once the system is implemented. A modal shift to public transport allows these vehicles to travel more efficiently. Increases in the number of commuters and the frequency of services can lead to greater demand and improved service quality. The fast-paced rhythm of urban life encourages people to value travel time savings, fare reductions, and enhanced convenience regardless of the mode of public transport—be it metro, bus, light rail, tram, ridesharing services, or conventional taxi (Ceder, 2021).

Park and Ride

The park-and-ride system comprises facilities in urban areas that serve as modal interchanges to shift private vehicle users to more sustainable modes of transport, such as mass public transportation, toward the CBD, where they conduct daily activities such as work or shopping (Ortega, Tóth, & Péter, 2021). The Growth Node Development Plan, proposed by the City Planning and Development Office, aims to expand economic activities in six strategic locations to ease congestion in the CBD. One of its transport-oriented development components includes park-and-ride facilities. Designated hubs with parking and terminal infrastructure include the Southbound Hub (Dontongan), Northbound Hub (Irisan), Cordillera Gateway Hub (Barangay Sto. Niño), and Kennon Road Hub. During the Investment Summit held in December 2022, private developers expressed interest in investing in parking and mobility infrastructure in the city.

4.3.2. Pilot Congestion Charge Deployment

In Stockholm, a pre-implementation trial allowed residents to experience and assess the proposed system (e.g., "Is it good?", "Is it bad?", "How can it be improved?"). Past reviews of congestion charging schemes—regardless of whether they were eventually implemented or rejected—indicate that pilot testing helps to address uncertainty and inform the public (Semoune et al., 2020; de Dios Ortúzar et al., 2021). Small-scale trials allow residents to understand better the system, not merely as a fee policy but as a potential solution. Familiarity with the benefits of the system may lead to greater acceptability.

4.3.3. Measures ti Convince Residents

A collaborative relationship between government units and citizens is crucial for increasing public engagement in policymaking. Based on the KIIs with local government offices and survey results, the following measures may enhance public acceptance of the proposed congestion charging system.

Improvement Information, Education, and Communication Campaign

Providing clear and detailed information about the proposed system proved difficult because the plan had not yet been finalized. Increasing awareness may improve public support. First, a well-reasoned justification for the system should be communicated, particularly as fee-based policies are often viewed unfavorably. However, individuals who commute using public transit, bicycles, or on foot are more inclined to support congestion charges than car users (Li et al., 2020). This justification may be well received given the previously discussed problem perception factor. Second, the objectives of the congestion charging system must be explicitly stated. Policymakers must communicate that the benefits of congestion charging exceed the associated costs by offering specific, comprehensible information about how the system meets its goals (Liu, Lucas, & Marsden, 2021). Third, the toll structure—including level, method, area, and time—must be established and clearly communicated before implementation. Lastly, it is important to demonstrate how the system operates and to provide a mechanism for public input during development. This can be achieved through a public consultation program designed to build understanding and awareness during the transition toward implementation.

Infromation Desk in Barangays

KIIs indicated that the Traffic Enforcement Unit had limited capacity to conduct public consultations about new traffic schemes. Barangay officials played a supporting role by disseminating information and managing public concerns. This approach proved effective when implementing the new rerouting scheme near Baguio Botanical Garden. Direct engagement with barangay stakeholders may improve information flow regarding the proposed measure.

Transparency of Revenue Allocation and Management

Transparency must be established early in the planning stage. According to the KII with CPDSO, no specific agency or office had been identified to manage congestion fee collection. Therefore, roles and responsibilities should be clearly defined before implementation. These include responsibilities related to system operation, fee collection, accounting, revenue distribution, and addressing system failures or unintended consequences.

5. CONCLUSION

TDM strategies have been applied to address transport-related issues such as traffic congestion. In the case of Baguio City, a congestion charging system, as a form of TDM, was proposed to manage congestion by reducing the number of vehicles operating in the central business district (CBD). This study examined the public acceptability of the proposed system and the factors influencing it from the perspective of city residents. The findings indicated that the strategy was perceived as "slightly unacceptable." This perception was shaped by several factors, including (a) limited information and awareness since most respondents reported hearing "nothing at all" about the strategy; (b) a belief that the system would be "less effective" in reducing traffic volume; and (c) concerns regarding the allocation of revenue, particularly for improving public transportation infrastructure. The study also found no significant difference in public acceptability across different transport modes, including private vehicle users, public transit users, and pedestrians. This suggests that the identified influencing factors similarly affected these groups.

In response to the low level of acceptability, the study recommends several transportation policy planning actions for the CBD of Baguio City. First, Policy Packaging refers to the combination of push and pull measures that can together form a more effective and acceptable solution to transportation challenges. Second, the Pilot Congestion Charge Deployment may be introduced to increase familiarity and understanding of the system among residents. Third, Measures to Improve Public Support may include strengthened information and education campaigns, the establishment of information desks at the barangay level, and increased transparency in how revenue from the system is allocated and managed.

This study has several limitations, which can serve as a basis for future research. The data were collected through KIIs with local government officials and an online survey using convenience sampling. Future studies may consider using in-person random sampling surveys, which would allow equal opportunity for selection and reduce potential bias in the respondent pool. Additionally, this study focused solely on residents of Baguio City. Further research may include tourists and a larger group of private vehicle users to understand better the public acceptability of the proposed congestion charging system. Despite these limitations, the study provides a useful foundation for the development of more effective and context-specific strategies to address traffic congestion and promote sustainable and equitable urban transportation systems.

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AGRICULTURAL EXTENSION IN AN URBAN INFORMAL SETTLEMENT DURING COVID-19: THE EFFECTIVENESS OF THE "TANIMANG BAYAN" INITIATIVE IN SITIO SAN ROQUE, NORTH TRIANGLE, QUEZON CITY

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ABSTRACT

The COVID-19 pandemic exposed deep inequalities in food access, particularly in urban informal settlements. This study examines the effectiveness of the "Tanimang Bayan" initiative, an urban agriculture project implemented in Sitio San Roque, Quezon City, as a form of agricultural extension during the pandemic. The research adopts a qualitative approach, drawing on data from key informant interviews, participant observation, and secondary sources. Findings indicate that the initiative provided a localized response to food insecurity by enhancing access to fresh produce and promoting community-led production. It also supported collective action and self-organization among residents, strengthening their autonomy in navigating structural limitations. These outcomes suggest that community-based agricultural interventions can contribute meaningfully to resilience-building and local food systems in marginalized urban contexts.

Keywords: Ecological issues in the city; Food security; Urban agricultural extension; Urban informal settlement; Urban transgression

1. INTRODUCTION

Sitio San Roque (SSR) is one of many informal settlements in Metro Manila that have long been excluded from the country's urban development agenda. As a result, its residents face ongoing threats to food security, livelihood, and housing (Collantes, 2021; Saguin, 2022). These vulnerabilities became more pronounced during the COVID-19 lockdown, when access to essential goods was restricted, employment became unstable, prices rose, and public transportation was disrupted (Bozyigit, 2021; Quetulio-Navarra et al., 2023; Afridi et al., 2020; Gutierrez et al, 2023; Agor et al., 2021). Despite the ongoing crisis, demolitions and evictions continued, which further marginalized the community (Collantes, 2021).

In the absence of adequate government support, SSR residents organized through the Kalipunan ng Damayang Mahihirap San Roque (KADAMAY-SR) and staged a protest that resulted in the arrest of over twenty individuals (Rosete, 2021). After initial resistance, the Quezon City Local Government Unit (QC LGU) provided only limited assistance (Abad, 2021). In response, KADAMAY-SR led grassroots relief operations, beginning with donation drives that eventually developed into more sustainable initiatives such as Tanimang Bayan (Community Planting) and Kusinang Bayan (Community Kitchen) (Quetulio-Navarra et al., 2023).

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Tanimang Bayan aimed to grow organic crops for the community and involved activities such as land preparation, organic input production, and harvesting of donated produce. These efforts were supported by the San Roque Vendors' Association (SRVA). By September 2021, the project had produced a variety of crops, including okra, eggplant, squash, and leafy greens. It also encouraged non-volunteers to begin home gardens and offer land for new farming plots.

This study explores how SSR residents developed urban agriculture knowledge and community resilience during the pandemic through the Tanimang Bayan initiative. It argues that community-led agricultural extension supports people-centered development in informal settlements by strengthening local agency and improving livelihoods through shared knowledge and collective participation.

By analyzing KADAMAY-SR as a localized model of agricultural extension, the study identifies the potential of urban-based approaches in areas with insecure land tenure, challenging environmental conditions, and limited institutional resources. These findings contribute to ongoing discussions on urban governance, land use, and sustainable food systems in rapidly urbanizing contexts.

2. LITERATURE STUDY

2.1. Agricultural Extension Models

Agricultural extension is generally understood as a process through which knowledge and technology are transferred from research institutions to farmers (FAO, 2003; Dwyer, 2022). It is often seen as a bridge linking farmers, research organizations, and educational institutions (Joshi et al., 2005). In the Philippines, the Agriculture and Fisheries Modernization Act (AFMA) designates agricultural extension as a central component of rural development. It defines extension as a service provided by government and non-government actors to support the technical, business, and social advancement of agricultural and fisheries communities (Ani and Correa, 2016). Primary responsibilities lie with the Department of Agriculture (DA), the Agricultural Training Institute (ATI), and local government units (LGUs), while universities, NGOs, private entities, and cooperatives occasionally contribute (Davis and Sulaiman, 2014). Despite this structure, challenges such as limited funding, poor coordination, insufficient training, and the lack of a unified national framework persist. Furthermore, current systems often fail to center farmers' lived experiences and knowledge in extension planning and delivery (Ani and Correa, 2016).

Traditional extension models have been critiqued for their hierarchical nature. The technology transfer model (Jiggins, 2011) is based on a one-way flow of knowledge from researchers to farmers, which has been found to marginalize local expertise and offer limited benefit to farmer livelihoods (Duveskog, 2013; Feder et al., 1999; Aker, 2011; Stoop, 1987). The feedback model introduced some farmer input but left decision-making largely with researchers (Stoop, 1987). Rhoades and Booth (1982) farmer-back-to-farmer model advanced participatory practice by integrating on-farm trials and farmer involvement throughout the research cycle, though issues of hierarchy and resource disparity remained (Bourner et al., 2001; Veerabhadraiah, 2012; Windon, 2019; Ostrom, 1996; Habacon, 2022). In response, more recent models developed by NGOs and grassroots groups have prioritized closer engagement with communities. These approaches promote co-learning and emphasize iterative, collaborative work between farmers and institutions. For example, the cassava-based program developed by the Nippon Foundation in Asia encouraged joint experimentation and long-term partnerships aimed at balancing productivity with ecological sustainability (Howeler, 2000). Such models move away from top-

down delivery and reflect a shift toward participatory knowledge-building rooted in local conditions.

2.2. Urban Farming in Metro Manila

Urban farming, defined as the cultivation of crops and livestock within city environments, has long been part of Metro Manila's food system planning (Saguin, 2022). Its origins date back to the 16th century, when communities grew crops along the Pasig River (Campilan et al., 2001). Today, urban agriculture takes many forms, including community gardens, rooftop farms, hydroponic systems, container gardening, and the use of vacant lots. The benefits of urban farming span multiple dimensions. Economically, it can improve food access and support income generation (Sonnino, 2009, cited in Saguin, 2022). Socially, it contributes to physical and mental well-being (De Zeeuw et al., 2011). Environmentally, it plays a role in reducing urban waste through composting and other regenerative practices (Hara et al., 2011; Sonnino, 2009).

Despite its potential, urban agriculture in the Philippines still lacks a clear national framework. The Local Government Code of 1991 is the only legal provision that addresses it, assigning program planning to LGUs. This has resulted in fragmented and sometimes overlapping efforts across cities and municipalities (Saguin & Cagampan, 2023). National government agencies and private sector partners typically provide technical support and resources to LGU-led initiatives, which often include backyard and vertical gardening projects. The Agricultural Training Institute (ATI) has contributed through programs like "ATIng Gulayan ng DA," which promotes organic gardening and integrated vegetable production in Quezon City. ATI also offers online training modules and instructional materials to encourage household-level gardening practices across urban areas.

2.3. Theoretical and Conceptual Framework of the Study

The study pplies the Social Interaction (SI) Model developed by Howe and Schnabel (2012) seen in Figure 1 to analyze how knowledge was built within the Tanimang Bayan initiative. The SI Model promotes learner-centered, face-to-face engagement, which reflects the participatory character of the efforts in Sitio San Roque. It outlines five interconnected components: Resource Access, Problem Development, Knowledge Construction, Information Exchange, and Motivation and Socialization. These elements help describe how residents shared knowledge, adapted techniques, and applied agricultural practices suited to their immediate needs. The model provides a useful lens for understanding how a community-based process supported the circulation of practical skills and information in response to the crisis.

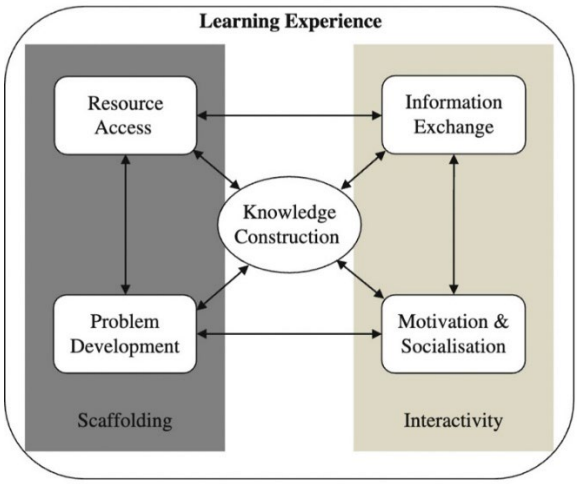

Figure 1 Social Interaction Model
(Howe and Schnabel, 2011)

Traditional extension efforts in the Philippines are still guided by the Transfer of Technology (ToT) model, where information flows from research institutions to farmers with limited opportunities for feedback or local adjustment. These programs are typically carried out by Municipal Agriculturists (MAOs) and Barangay Extension Workers (BEWs), and follow a top-down approach (Declaro-Ruedas, 2019). In contrast, this study examines how the KADAMAY-SR approach responded to the specific circumstances of an informal urban community. It highlights how the group used context-based strategies that relied on participation, local initiative, and collective learning. The contrast reveals how conventional systems may fall short in addressing the realities of communities like Sitio San Roque.

The Tanimang Bayan project stands out as one of the first urban agriculture efforts initiated by an informal settlement community during the COVID-19 pandemic. This study explores how KADAMAY-SR and Sitio San Roque residents connected urban agriculture with improved food access, applied farming knowledge through lived experience, and addressed both food scarcity and the threat of displacement. The analysis considers how this initiative was shaped by its urban location and the conditions of informality. Using the SI Model, the study identifies the components of the knowledge-sharing process and compares them with those found in state-led extension models. In the case of KADAMAY-SR, the priority was to expand access to food and resist the pressures of land redevelopment (see Figure 2).

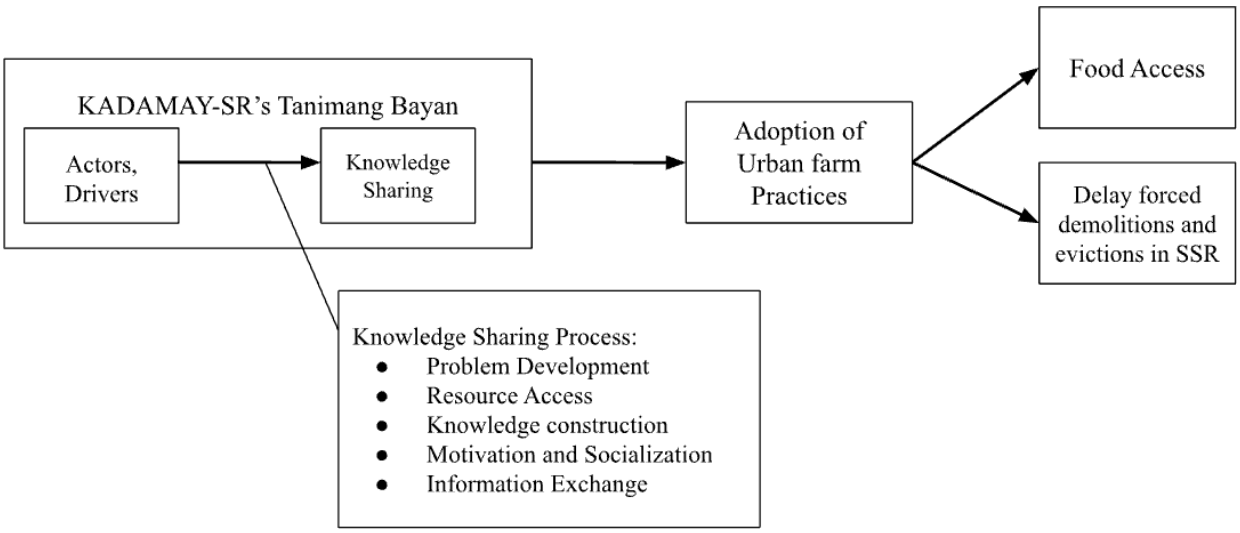

Figure 2 Conceptual Framework

3. METHODS

This study applied a qualitative case study approach to examine the Tanimang Bayan initiative led by KADAMAY-SR in Sitio San Roque, Quezon City. A case study refers to a detailed investigation of a specific subject such as a place, event, or community (Starman, 2013). Given that Tanimang Bayan is the first urban farming initiative organized by an informal settlement during the COVID-19 pandemic, this approach was considered suitable for documenting its development and analyzing it as a distinct extension model. Qualitative research offers a narrative framework that reflects the lived experiences of participants (Crossman et al., 2020), which complements the descriptive nature of case study research.

Sitio San Roque (SSR), a 37-hectare informal settlement located in Quezon City's North Triangle, was the site of this investigation (see Figure 3). Bordered by North Avenue, Quezon Avenue, North EDSA, and Agham Road, SSR was once home to more than 24,500 families. Currently under redevelopment through a partnership between the National Housing Authority

(NHA) and Ayala Land, the area has undergone significant changes. Based on a 2022 community map, SSR contains six sections: Area F, Area H, Area I, Area Dubai, Area J1, and Area J2. This study concentrated on Area I, the initial location of the Tanimang Bayan farm.

A total of 21 participants were selected through purposive sampling based on their proximity to or involvement in the urban farming initiative. This group included Tanimang Bayan leaders, volunteers, residents not directly involved but affected by the project, and private security guards stationed near the farming site. KADAMAY-SR members and barangay officials identified the participants. The interviews were conducted face-to-face between April 20 and May 5, 2024, with participants informed of their rights, including anonymity, voluntary participation, and the option to decline any questions. Each interview followed a semi-structured format adapted to the participant's role in the community.

Figure 3 A Partial Map of Sitio San Roque and Its Landmarks

To fill the gap left by outdated spatial data, the study included a counter-mapping activity with local residents. While earlier maps existed through groups such as the UP Junior Philippine Geographical Society, the latest available version dated back to 2021. Community members worked together to identify urban farm locations and barriers such as fences and checkpoints, which were later transposed onto a 2024 Google Maps base layer. These spatial data complemented interview questions, which focused on participation, organizational structure, access to resources, and knowledge exchange. Respondents also discussed their broader experiences as residents of an informal settlement.

Thematic analysis guided the interpretation of collected data. The study used the Social Interaction (SI) Model by Howe and Schnabel (2012) as an analytical lens, drawing on its components: Resource Access, Problem Development, Knowledge Construction, Motivation and Socialization, and Information Exchange.

4. RESULTS AND DISCUSSION

4.1. Context and Development of Tanimang Bayan and KADAMAY San Roque

The Tanimang Bayan initiative was established by the Kalipunan ng Damayang Mahihirap San Roque (KADAMAY-SR), a grassroots organization based in Sitio San Roque, with the initial

goal of supplying fresh produce for their Kusinang Bayan feeding program. Early crops such as garlic and onions were selected to reduce ingredient costs. As support grew from progressive groups and the QC LGU, the initiative expanded its goal to providing a stable source of organic vegetables for the wider community during the COVID-19 lockdown. By mid-2021, farm sites had grown beyond their original location on Capricorn Street to include Camote and Moral Streets, producing vegetables for more than 300 households or approximately 1,500 residents per harvest (Garcia, 2021).

Residents involved in Tanimang Bayan were mostly migrants from provinces such as Davao, Bicol, Eastern Samar, Antique, North Cotabato, and Catanduanes. Based on accounts from KADAMAY-SR leaders and demographic surveys, the community reflects typical gendered roles: men worked in construction or informal jobs, and women handled domestic responsibilities or vending. Volunteers like Beth, Marilyn, and Annesty had rural farming experience, while others such as Mary and Lucile learned to grow crops in SSR for the first time. A local gardening trend known as "plantita" culture also motivated some residents. Reasons for participation ranged from lowering household expenses to improving mental well-being and food safety. According to KADAMAY-SR chair Estrelieta "Ka Inday," the effort built on earlier land cultivation in SSR that began when she arrived in 1983. Several areas in Sitio San Roque are shown in Figure 4.

Figure 4 Sitio San Roque Map with Different Areas

4.2. Knowledge Transfer as Grassroots Agricultural Extension

The Tanimang Bayan initiative led by KADAMAY-SR offers a practical alternative to conventional agricultural extension. In contrast to the Transfer of Technology (ToT) model, where knowledge flows in a top-down direction from trained extensionists to farmers, the KADAMAY-SR model involves residents acting as both knowledge producers and disseminators. This grassroots approach draws from the lived experiences and priorities of the community, particularly in relation to food access and urban land struggles. The model aligns with participatory frameworks such as Farmer Participatory Research (FPR), Participatory Technology Development (PTD), and Farming Systems Research (FSR), which stress the role of

farmers in shaping knowledge through collaboration and context-based adaptation (Jaganathan & Thamban, 2017; Mohapatra & Shanmugasundaram, 2016).

Sitio San Roque residents and KADAMAY-SR members did not rely on formal extension agents. Instead, they organized discussions, shared farming knowledge, and formed partnerships with advocacy groups to address the unique challenges of urban farming in an informal settlement. These actions reflect the kind of decentralized and community-rooted extension work described in participatory approaches, with KADAMAY-SR residents taking on both planning and implementation roles (see Table 1).

Table 1 Innovative Extension Approaches, Key Characteristics, and Similarity to the KADAMAY-SR Approach

Innovative Extension Approaches	Key Characteristics	Similarity to the KADAMAY-SR Approach
Farmer Participatory Research (FPR)	Research questions are developed together with selected farmers or the whole village, and villagers perform and monitor experiments with scientists.	KADAMAY-SR members and SSR residents worked together to identify issues they wished to address through Tanimang Bayan.
Participatory Technology Development (PTD)	Sponsored technology is tested, suitably modified, and refined by the farmers in their fields, leading to their viability and acceptance in their farming situations.	KADAMAY-SR built networks to gain access to urban farming knowledge, technology, and resources. SAKA-UMA modified their farming workshop to cater to the urban informal context of SSR.
Farming System Research (FSR)	Identify connections between farms and the natural, social, and economic context. Farming systems are not static but dynamic.	KADAMAY-SR members and SSR residents adjusted their strategies based on developments in the urban informal settlement context. Case 1: KADAMAY-SR members strategically placed farm plots in demolished areas. Case 2: SSR residents created trellises from ropes instead of bringing in new building materials (wood, bamboo) as per internal protocols with private guards.

Two central problems led to the creation of Tanimang Bayan. First, residents faced rising prices for essential food items, especially vegetables. Several respondents described how planting garlic, onion, and leafy greens helped reduce their daily expenses. KADAMAY-SR members recalled how, at the height of the lockdown, they held informal surveys and chapter meetings to address shared concerns. For many, urban farming offered a practical response to limited income and market dependence.

Second, the residents faced barriers related to land access and limited agricultural inputs. The lack of fertile soil, irrigation systems, and farming tools made it difficult to sustain gardens. Volunteers like Edith and Annabel described how they adapted by planting in reused containers, conserving water, or making simple trellises from ropes. These responses reflect a form of local innovation shaped by both scarcity and environmental constraint.

To build technical capacity, KADAMAY-SR collaborated with two groups, SAKA (Sama-samang Artista para sa Kilusang Agraryo) and UMA (Unyon ng mga Manggagawa sa Agrikultura). In 2021, these groups led a hands-on workshop that focused on organic farming, hydroponics, and fertilizer production. The workshop was based on Bungkalan, UMA's publication on peasant-led agriculture in Hacienda Luisita. Rather than replicate rural practices directly, facilitators modified their lessons to fit Sitio San Roque's dense urban setting. The training featured PowerPoint presentations and group discussions, followed by practical activities such as seed selection, composting, and land preparation. Figure 5 shows the Network map of Tanimang Bayan and KADAMAY-SR, in relation with knowledge and skills, as well as resource and fundings.

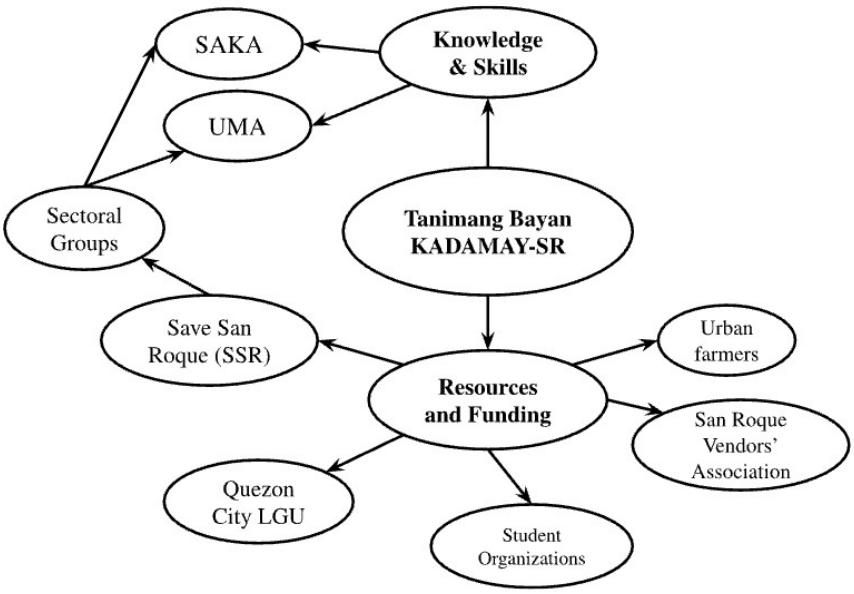

Figure 5 Network map of Tanimang Bayan and KADAMAY-SR

Residents were taught how to produce organic inputs like Fermented Fruit Juice (FFJ), Fermented Plant Juice (FPJ), and Indigenous Microorganisms (IMO) using leftover kitchen waste, bananas, and steamed rice. These inputs helped address the absence of store-bought fertilizers. The workshop introduced soil-depth methods ("1 ruler rule"), hydroponic planting in reused containers, and seed-saving techniques, which residents later used in their own gardens. Volunteers appreciated that the training supported sustainable farming without relying on expensive materials.

The exchange of knowledge did not end with the workshop. Residents who joined the training passed on what they learned to their neighbors. Sally, for instance, shared planting techniques and seeds she received from Ka Inday with other SSR households. Lourdes and Annabel began composting at home using vegetable scraps. Gina created her own pots from recycled bottles. Several participants noted that residents tended to adopt new techniques only after seeing them succeed in practice, which reflects "Diffusion of Innovations" theory. In Sitio San Roque, visible results encouraged more households to try composting, vertical planting, or seed sharing.

The knowledge exchange occurred mostly through personal interaction rather than formal channels. Residents often approached volunteers to ask about planting schedules, pest control, or soil preparation. The volunteers responded with verbal advice or physical demonstrations. These conversations happened near homes, community spaces, or along the pathways that connected the farming plots. This face-to-face learning process reflects "socialization" mode of knowledge creation where tacit knowledge circulates through direct and embodied experiences. Figure 6 illustrates the knowledge transfer process in Tanimang Bayan.

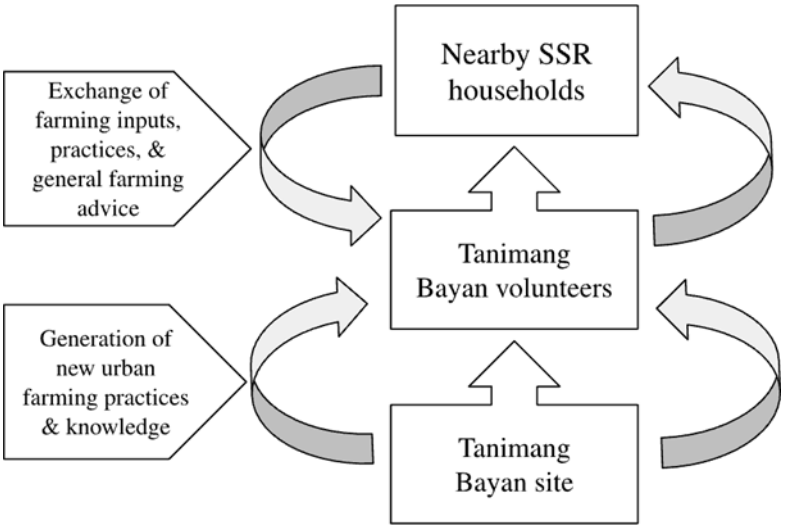

Figure 6 Visual Representation of the Knowledge Transfer Process in Tanimang Bayan

4.3. Constraints to Scaling the Initiative

Tanimang Bayan faced increasing spatial restrictions in Sitio San Roque as residents navigated a complex set of internal protocols and external surveillance. Building or modifying urban gardens required official permits from both the barangay and the National Housing Authority (NHA). Private guards monitored compliance, sometimes dismantling structures like trellises or fences that lacked prior approval. Volunteers such as Marilyn and Edith described how even lightweight materials like bamboo poles or rope trellises were subject to inspection. Residents needed to specify the exact number of building materials and undergo approval from multiple offices, often without any guarantee of permission. These conditions discouraged expansion efforts and made the farming process unpredictable. Figure 7 below illustrates the density of guard posts and fences across Sitio San Roque in 2024. The spatial configuration shows how guards were positioned at key entry points and street intersections, limiting free movement and complicating the maintenance or expansion of farming plots.

Figure 7 SSR map of all the guard stations in Sitio San Roque.

The pressure from surveillance and land control coincided with demolition efforts in designated "danger zones." The original farming sites on Capricorn, Moral, and Camote Streets in Area I were gradually rendered inaccessible after 2021. Households in Areas J1 and J2 faced similar threats as development projects proceeded. Some residents referred to Area I as already controlled by Makati Development Corporation (MDC), despite the absence of active construction. Respondents reported that security posts, cemented pathways, and fencing blocked access to key farm plots. As families relocated or self-demolished, farming activities decreased, and knowledge-sharing practices weakened. Volunteers described the psychological toll of losing access to long-tended gardens and being forced to abandon productive plots with no certainty of replacement. Sitio San Roque Map (2022 vs 2024) in Figure 8 illustrates the demolition and relocation patterns affecting Tanimang Bayan sites.

Figure 8 Sitio San Roque Map (2022 vs 2024)

Resource limitations also affected the continuity of the initiative. During the early phases of Tanimang Bayan, external groups such as Save San Roque, the Quezon City LGU, and student organizations helped provide inputs like soil, tools, and seeds. However, volunteers reported that some of the donated land had poor soil quality, while basic materials such as water hoses and containers were scarce. The price of ingredients used in organic fertilizers also rose, making it harder to sustain production. For instance, the cost of sugar for Fermented Fruit Juice (FFJ) doubled, and rice used for Indigenous Microorganisms (IMO) became less affordable. Without consistent external support, volunteers began relying on recycled materials and informal donations, which limited both the scale and variety of crops they could grow.

These constraints contributed to a decline in active participation. Before the pandemic, over thirty residents volunteered regularly at Tanimang Bayan sites. By 2024, this number had dropped to around six. The smaller site on Ilang-Ilang Street required fewer hands, but respondents linked the reduction in volunteerism to the uncertainty surrounding land tenure and the return of paid work after the lockdown. Volunteers like Annesty and Ka Inday also noted a drop in the regular application of techniques learned from training. Organic fertilizer use became sporadic, and some practices, like hydroponics, were no longer in use due to cost and water scarcity. Although some residents continued composting and seed preservation, overall knowledge retention had declined. Despite these challenges, pockets of resilience remained. Residents such as Sally adapted to internal protocols and created protected household gardens using concrete walls and netting. Others shared leftover seeds or tips on alternative pest control methods. However, the absence of secure land tenure and formal support mechanisms continued to constrain the broader replication of Tanimang Bayan practices. Without stronger safeguards for spatial access and resource flow, the initiative remains at risk of contraction rather than scale-up.

4.4. Adaptive Strategies and Community Resilience

Residents of Sitio San Roque adopted several farming practices to respond to the limitations they encountered. When formal organic inputs became expensive or unavailable, volunteers modified their application techniques or substituted materials. Annesty and other members of Tanimang Bayan replaced Oriental Herbal Nutrients (OHN) with garlic bulbs, planted beside leafy crops like pechay to repel pests. Some residents planted marigolds to attract pollinators and deter insects. These site-specific responses required no external inputs and drew from local experimentation. In another case, ropes and discarded cloth replaced wooden stakes in trellis building, following internal rules that prohibited new construction materials such as bamboo or metal.

Space limitations led residents to adopt vertical planting methods. Gina, Lourdes, and Sally reused plastic containers and bottles to raise crops like okra and pechay in narrow alleyways or along home fences. Others developed raised-bed plots by layering kitchen waste, soil, and ashes to create fertile layers on concrete surfaces. A few households rerouted dishwashing water for irrigation, especially during periods of water scarcity. These small-scale innovations allowed farming to continue despite limited land access and unpredictable water supply. Residents who had once relied on open plots began to cultivate in corners of their dwellings, making use of walls, windowsills, and hollow blocks.

The decision to maintain production under such constraints reflected not only ingenuity but a broader sense of self-reliance. Edith and Sally shared that harvests, though smaller, remained sufficient for family use or occasional sharing with neighbors. These outcomes helped sustain interest in home gardening even after larger community plots had been lost. Residents viewed these efforts as practical rather than symbolic. Their purpose was not to reproduce the scale of Tanimang Bayan but to extend its spirit of survival into fragmented urban spaces.

Residents passed down knowledge both formally and informally. Sally often repeated tips from Ka Inday to younger neighbors, such as how to identify when a seedling should be transferred to deeper soil. Several mothers involved their children in watering schedules or compost turning, introducing farming as a shared household activity. Others like Lourdes exchanged planting routines and pest control advice with nearby friends. These moments became opportunities to reinforce community ties through practical collaboration. Even short conversations while passing each other on the way to the water pump or sari-sari store often included updates about crops or tips for natural fertilizers.

Spatial dispersion did not stop the continuation of learning. As more families were relocated or scattered across areas like J1, Dubai, or F, they carried with them knowledge of how to make IMO or use trellises without bamboo. This helped distribute the Tanimang Bayan approach beyond its original physical boundary. While volunteers were no longer clustered in one location, residents recognized each other as former participants and reestablished exchanges in their new surroundings. Some even restarted gardens in relocation sites, applying what they learned during earlier training sessions. This created a modest but persistent presence of urban farming practices across the community.

These localized exchanges allowed for continued application and adjustment of agricultural practices. Residents reported modifying the proportions of FFJ and FPJ recipes based on climate or crop condition. Others experimented with new seed-saving methods to adjust to shorter planting cycles. In the absence of regular workshops, community knowledge still evolved. These changes were driven not by formal instruction but by day-to-day needs and observations. The result was a body of informal learning that adjusted to Sitio San Roque's evolving physical and social context.

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4.5. Political and Social Implications of the Tanimang Bayan Approach

Tanimang Bayan has not only addressed food insecurity but also served as a response to the threat of forced eviction in Sitio San Roque. The farming initiative, particularly during the early stages of the pandemic, helped delay demolition efforts by occupying contested spaces with visible, productive activity. KADAMAY-SR volunteers described how the farm's presence limited the movement of private guards and temporarily halted land clearing. Public visibility and strategic use of green space contributed to a form of resistance that did not rely solely on protest or legal mechanisms. In 2020, QC Mayor Joy Belmonte voiced support for the initiative, citing the importance of protecting community-based food sources. Her intervention discouraged harassment by private guards and developers and signaled that the local government recognized the farm's value beyond subsistence.

Institutional support from the QC LGU gave the farm a temporary form of political protection. This allowed KADAMAY-SR to expand the project across multiple sites between 2020 and 2021. In turn, residents associated urban farming with political agency, not only as a tool for food access but as leverage in their broader struggle for housing rights. Volunteers expressed that the initiative helped shift how SSR residents were perceived. Instead of being seen as obstacles to development, they began to appear as organized, self-sufficient actors contributing to urban sustainability. Some residents believed that such visibility postponed further demolition, especially in high-risk areas such as Area I and J1. While the farm did not prevent redevelopment altogether, it reframed land occupation as a legitimate community effort grounded in care work, food sovereignty, and public health.

These developments reflect a broader need to rethink agricultural extension within urban contexts. Compared to the Transfer of Technology (ToT) model, which treats knowledge as a commodity passed from trained professionals to passive recipients, the KADAMAY-SR model treated extension as a political and relational process. Sitio San Roque residents not only applied new skills but also organized collectively, created networks, and adapted their strategies based on lived experience. The farm's success did not depend on state-led interventions but on local initiative and alliances with advocacy groups, students, and supportive government officials. This form of extension blurred the line between food access and social mobilization, demonstrating how urban agriculture could function as a platform for political participation and place-making.

This model aligns with the principles of People-Centered Food Systems, as articulated in the UN FAO's 2023 framework. These systems emphasize food sovereignty, grassroots decision-making, and the protection of informal producers who face displacement or exclusion. Tanimang Bayan reflects these values through its focus on participatory knowledge creation, ecological practices, and neighborhood-based distribution. Residents did not rely on external certification or formal markets but shared seeds, compost, and technical advice within the community. This approach positioned food production as part of a larger political demand: the right to remain in place and to shape one's environment. In that sense, Tanimang Bayan redefined urban farming as both a survival tactic and a strategy for asserting housing justice. Figure 9 illustrates the KADAMAY San Roque Approach.

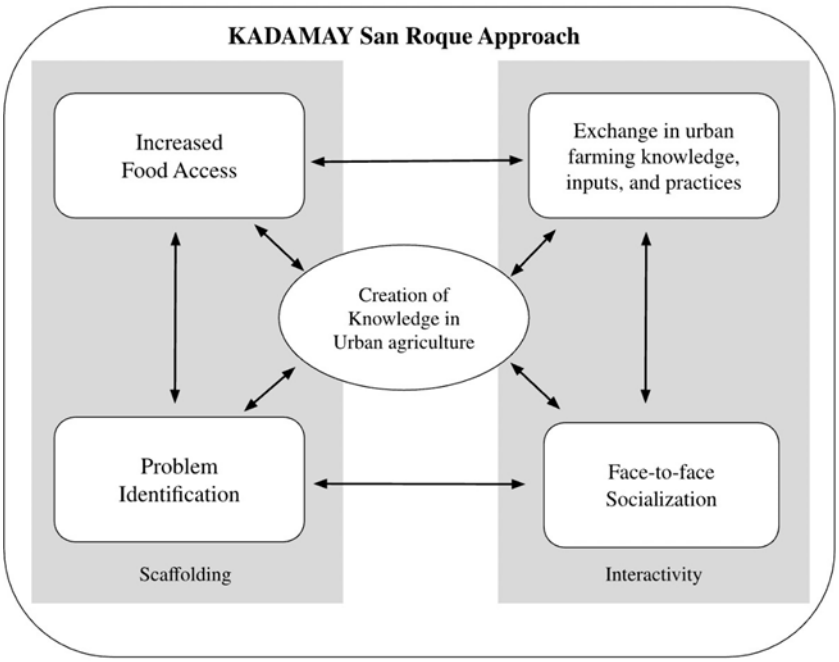

Figure 9 KADAMAYSan Roque Approach: A Community-based Knowledge Model in Urban Agriculture

5. CONCLUSION

This study examined the Tanimang Bayan initiative led by KADAMAY-SR to understand how agricultural extension can emerge from within an informal urban community. In the absence of formal extension services, residents organized their own knowledge-sharing systems to respond to food insecurity and limited state support during the COVID-19 lockdown. KADAMAY-SR partnered with advocacy groups to provide organic farming workshops, which helped residents cultivate urban plots and exchange practices. These workshops contributed not only to food production but also to the cultivation of political awareness, as farming became a response to both hunger and displacement.

The visibility of Tanimang Bayan influenced nearby households to replicate growing methods in their own spaces. Knowledge circulated through informal social interactions, with volunteers demonstrating techniques or distributing seeds to interested neighbors. As an alternative to top-down models, this participatory approach allowed residents to function as both learners and facilitators. However, threats to land security and inconsistent resource access disrupted volunteer efforts and affected the continuity of knowledge transfer.

The initiative illustrates how urban farming intersects with broader struggles over housing rights and land tenure. KADAMAY-SR's cultivation of demolished sites challenged dominant urban development agendas and drew attention from local government, which offered material support. This political recognition provided temporary protection but did not resolve the risk of eviction. The Tanimang Bayan case shows that agricultural extension is not only a matter of technical assistance but also a form of grassroots advocacy grounded in the right to stay in the city.

Further research should explore the political dimensions of grassroots farming and its role in resisting urban displacement. This study is limited by its scope as a single-site case during a specific post-lockdown period. The findings reflect the experiences of a small number of

residents, and outcomes may differ in other informal settlements with different governance structures or histories of eviction. Despite these constraints, the insights contribute to understanding how local adaptation shapes both agricultural practice and political resistance. Comparative studies across informal settlements may reveal how local knowledge systems support not only food access but also collective action.

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PROFILING OF PHYSICAL ACTIVITY USAGE IN SELECTED URBAN GREEN SPACES IN MARIKINA CITY

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ABSTRACT

Urban Green Spaces (UGS) play an important role in providing opportunities for physical activity in urbanized cities. This observational cross-sectional study aims to profile two selected UGS, namely Marikina River Park and Marikina Heights Park Complex, in Marikina City, in the context of their use for physical activity and recreation. Interviews with two government officials were conducted to collect data on the historical background of the selected parks. Systematic observation, using the System for Observation of Play and Recreation in Communities tool, was conducted to observe park visitors and their physical activity for four days in each park. Each park's target area's characteristics were identified and assessed before the observation period. Findings from the interviews indicate that the selected UGS were established for community and personal development. Each park contained areas suited for general use, rest, and socialization or for specific activities. Observations indicate that most visitors use the UGS for physical activity. A total of 47.91% engaged in moderate activity, 3.74% in vigorous activity, and 48.34% were observed to be sedentary. Various types of activity were recorded, with walking, biking, and dancing being the most common. Walking and biking visitors often used the park as part of their daily route. The majority of park visitors were male (52.55%), while females accounted for 47.45%. Teenagers made up the largest observed age group (49.83%), followed by adults (33.26%), children (13.62%), and older adults (3.30%). These findings indicate that the selected UGS serve their intended purpose, with most visitors engaging in physical activity. Nevertheless, further improvements aimed at specific activities may help attract demographic groups that were less represented. The physical design of the parks and the presence of structured programs could help increase participation among these groups. A built environment and organized activity can be used to encourage physical activity for specific demographics of park visitors.

Keywords: Physical activity; Public parks; Recreation; SOPARC; Urban green spaces

1. INTRODUCTION

Physical Activity (PA) is an important factor in health and wellness. Yet, in 2016, 27.5% of the world's adult population was found to have insufficient PA (Yeung & Johnston, 2019). Six years later, the World Health Organization (WHO) reported that this percentage remained largely unchanged in 2022 (WHO, 2022a). Between these years, the COVID-19 pandemic further affected PA among people across all age groups. Restrictions limited opportunities for outdoor exercise. As a result, the global population experienced a decline in PA and a rise in sedentary behavior (Park et al., 2022). Countries are now addressing the negative impact of COVID-19 on PA and public health.

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Urban Green Spaces (UGS), often used interchangeably with green spaces, are viewed as a significant contributor to promoting PA, particularly in post-pandemic society. Although many areas may be considered UGS, Taylor and Hochuli (2017) define them as vegetation within urban environments. These include parks, gardens, yards, forests, and farms. These green spaces can serve as places for leisure, recreation, and contact with nature (WHO, 2016) and are linked to increased PA with associated health benefits (Pietilä et al., 2015).

The connection between UGS and PA is shaped by the characteristics of the space and how it is used. Previous studies have identified infrastructure, condition, accessibility, aesthetics, safety, and policies as key aspects of UGS (Bedimo-Rung et al., 2005). These include both built and natural elements. Multiple studies associate such features with park-based PA (Kaczynski et al., 2014; Smith et al., 2017). Certain areas are designed for exercise, sports, or other physical activities. Paved paths are commonly used for walking or jogging, playgrounds support unstructured play among children, and sports facilities are used for organized activities. The presence or absence of these elements can affect the type and intensity of park-based PA (McCormack et al., 2014).

These characteristics influence the pattern of PA and the diversity of park users. Koohsari et al. (2015) observed park use across ages, genders, ethnicities, and socioeconomic backgrounds. Kaczynski et al. (2014) highlighted the importance of providing diverse features in UGS to support PA across generations.

UGS can provide valuable leisure, recreation, and exercise opportunities to support health, especially in highly urbanized Metro Manila, where physical inactivity is common. Marikina City, a component of Metro Manila, contains 96 developed parks and open spaces. With several health-oriented programs, WHO and the Alliance for Healthy Cities recognized it as one of Asia's healthiest cities in the early 2000s (Mercadero, 2021). Marikina guides other regional cities as a model for urban health in Metro Manila (WHO, 2003). Understanding how UGS in the city are used can support efforts to address physical inactivity. These insights can inform policy and initiatives by local governments to develop public parks that facilitate PA and community engagement.

This study profiles two selected UGSs in Marikina City. It explores how local community members participate in PA within these spaces. The study aims to:

a) Describe the historical background, location, and geography of the two selected UGS in Marikina City
b) Examine the built environment, facilities, and amenities of the selected parks, along with their use and management
c) Explore how the local community uses these UGS for physical activity and recreation

UGS research has grown in recent years (Taylor & Hochuli, 2017), yet questions remain about their role in promoting PA. Koohsari et al. (2015) identified areas requiring further investigation, including the influence of individual characteristics on PA. Systematic reviews reveal mixed results on how UGS features relate to PA (Ding et al., 2011; Jansson et al., 2019; Joseph & Maddock, 2016; Zhang et al., 2019). This study contributes to ongoing efforts to clarify these relationships through additional research.

The COVID-19 pandemic has shifted public needs related to PA and UGS. Honey-Rosés et al. (2021) questioned how public design and use of UGS will evolve in response to the pandemic. This study adds to the growing body of work that observes how UGS are used for recreation, leisure, and exercise in the post-pandemic context.

Several systematic reviews also highlight a lack of studies conducted in communities beyond the United States (Evenson et al., 2016; Ding et al., 2011; Smith et al., 2017; Zhang et al., 2019). Given cultural, environmental, and lifestyle differences among countries, results from one setting may not

apply elsewhere. This research explores the topic in the Philippine context, particularly in Marikina City. In light of the prevalence of insufficient PA in the country (WHO, 2022b), the study aims to assess how urban public parks may help promote PA among Filipinos of various ages and genders.

As WHO's Global Action Plan on Physical Activity outlines, access to and use of UGS are key components in building active environments. The findings of this study may support the city of Marikina and its residents in creating a healthier, more active setting. It offers insights into the outcomes of previous programs, such as the Healthy Tourist Parks and Urban River Rehabilitation, and assesses whether these initiatives have met their goals. In addition, the results may help guide urban planners and policymakers in other cities across the Philippines to improve urban design and maximize UGS for community benefit.

2. LITERATURE STUDY

In the context of rapid change, technological advancement, and urban development, physical activity (PA) and health are often overlooked in favor of infrastructure and economic growth. This is reflected in the high global incidence of insufficient PA. The COVID-19 pandemic emphasized the need for spaces dedicated to PA and recreation to support health and well-being. UGS has consistently been associated with PA and health outcomes. Specific characteristics of these spaces are linked to varying types and intensities of PA among urban residents across gender, age, ethnicity, and socioeconomic backgrounds. While numerous studies have examined the relationship between UGS and PA in developed countries, there remains limited research on how these spaces promote PA in the Philippines, despite the country's network of accessible public parks and green spaces.

2.1. The Role of Urban Green Spaces in Promoting Physical Activity

Definitions of UGS vary. Taylor and Hochuli (2017) reviewed the term's usage across multiple disciplines and noted that no universally accepted definition of "green space" exists. In urban contexts, UGS are commonly interpreted as vegetation within city environments. This includes urban parks, gardens, forests, farms, and, in some cases, blue spaces such as water bodies.

As one example of UGS, public parks have been shown to contribute meaningfully to PA (Cohen et al., 2007). These spaces offer opportunities for local communities to engage in exercise. Pietilä et al. (2015) found that access to and presence of green spaces were positively linked to increased PA and perceived health improvements. The WHO's Global Action Plan on Physical Activity (2022a) also highlights the role of active environments in increasing global PA levels, which includes public access to green, open spaces for sport and play.

Physical activity has consistently been identified as a key element in supporting overall wellness. Yeung and Johnston (2019) reported that global physical inactivity reached 27.5% in 2016. The study identified several contributing factors to reduced PA, including urban designs focused on speed, convenience, density, comfort, insufficient infrastructure supporting active transport; and limited access to green and recreational areas. WHO (2022b) later reported that this inactivity rate had not changed significantly by 2022.

The COVID-19 pandemic further affected global PA levels. Park et al. (2022), examining the pandemic's early effects, observed a general decline in PA and increased sedentary behavior. Similar findings were reported in children by Dunton et al. (2020). Both studies described these trends as a public health concern and called for increased promotion of PA. Park et al. (2022) noted the role of residential and neighborhood environments in addressing the pandemic's effects. Yang et al. (2021) supported this by showing that decreases in leisure-time PA were less pronounced in neighborhoods with more urban greenery, suggesting that these areas may help mitigate inactivity. Their study also found increased total PA duration in country parks, emphasizing the role of UGS as important spaces

for PA, particularly during health emergencies. Overall, the pandemic reinforced the significance of regular PA and access to well-designed public open spaces (WHO, 2022a).

2.2. The Link between Urban Green Spaces, Physical Activity, and Health

Urban Green Spaces (UGS) offer a practical approach to increasing contact with nature, preserving city biodiversity, reducing environmental risks, and enhancing health and quality of life among urban populations (WHO, 2017). The World Health Organization has emphasized the importance of making public green spaces accessible to various groups living in urban areas. These spaces have been associated with various benefits across physical, psychological, social, economic, and environmental dimensions for individuals and communities (Bedimo-Rung et al., 2005). A systematic review conducted by Twohig-Bennett and Jones (2018) supports these findings by presenting evidence from multiple studies that link exposure to green spaces with a broad range of health outcomes. These outcomes include improvements in cardiovascular and respiratory health, neurological development, pregnancy-related outcomes, and reductions in the incidence of type II diabetes and stroke.

The mechanisms through which green spaces support health include opportunities for relaxation and psychological recovery, strengthened social relationships, improved immune function, increased physical activity and fitness, reduced obesity, decreased air and noise pollution, lower urban heat accumulation, greater environmental awareness, and better sleep resulting from exposure to sunlight (WHO, 2016). Many studies have specifically investigated how physical activity in green spaces contributes to these health benefits. In the context of public parks, the frequency of visits and the specific features of the parks have been associated with improvements in health, social cohesion, environmental awareness, and local economies.

To better understand how urban green spaces contribute to physical activity and related health outcomes, Bedimo-Rung et al. (2005) developed a conceptual model. Figure 1 presents the connections between specific park characteristics, patterns of park-based physical activity, and their resulting physical, psychological, and social health benefits. The model illustrates how park design elements, access, and user engagement can improve health and well-being.

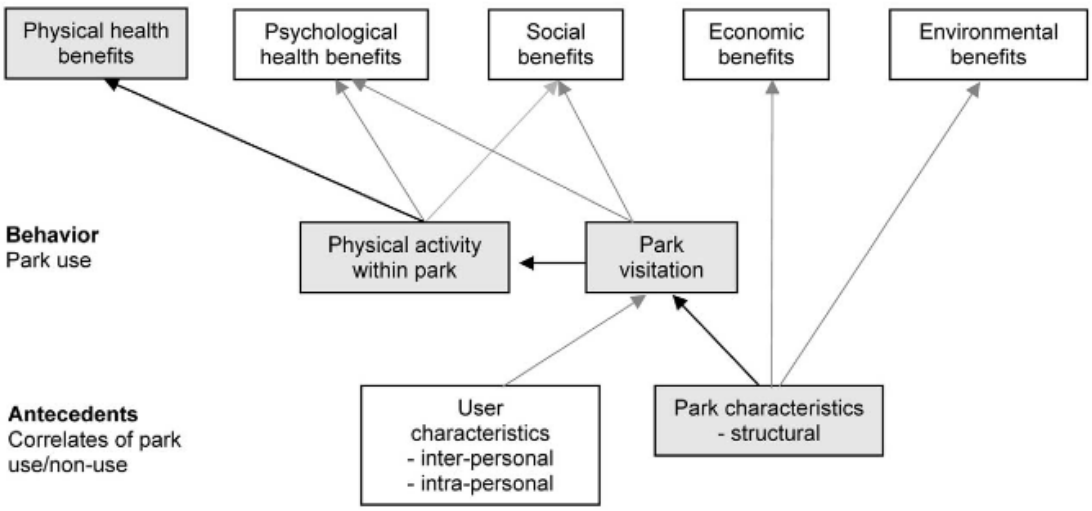

Figure 1 The relationship between parks and physical activity
(Bedimo-Rung et al., 2005)

2.3. Research Into Urban Green Spaces and Physical Activity

The study of green spaces, particularly in health and PA, has emerged as an area of growing interest over the last decade. This research explores the relationships among PA, UGS use, park characteristics, and user demographics (Taylor & Hochuli, 2017). Koohsari et al. (2015) emphasized the need for further research to examine how UGS characteristics influence the demographics of park

users and the nature of park-based PA. A systematic review conducted by Joseph and Maddock (2016) examined multiple observational studies on park-based PA. It noted that most existing research is based in the United States (U.S.), with three times as many studies as those conducted in other countries. This finding is echoed in other reviews (Evenson et al., 2016; Ding et al., 2011; Smith et al., 2017; Zhang et al., 2019), all of which call for expanded research in contexts outside the U.S. (Evenson et al., 2016).

Among these studies, the System for Observing Play and Recreation in Communities (SOPARC), developed by McKenzie et al., is a widely used tool for conducting systematic observation in park settings (Joseph & Maddock, 2016). SOPARC has been tested for reliability and feasibility and includes a well-established research protocol (McKenzie et al., 2006a; McKenzie et al., 2006b). A systematic review by Evenson et al. (2016) analyzed how SOPARC has been applied in various studies. The review also noted how modifications to the tool allowed researchers to meet specific study objectives. These adjustments were effective in evaluating smaller parks, minimizing the risk of double-counting visitors, and supporting the tool's adaptability to different community contexts and research goals.

2.4. Urban Green Space Characteristics Facilitating Physical Activity

Specific spatial and environmental characteristics can influence the relationship between the use of UGS and PA. According to WHO (2016), such characteristics are associated with health outcomes, which may be either beneficial or harmful. In a conceptual model developed by Bedimo-Rung et al. (2005), as illustrated in Figure 2, park attributes are classified into six major categories: features, condition, access, aesthetics, safety, and policies. Similar groupings have been used in other studies examining parks' environmental and structural aspects (Pietilä et al., 2015; Zhang et al., 2019; Padial-Ruz et al., 2021).

A systematic review by Zhang et al. (2019) sought to identify the characteristics most strongly associated with park-based PA. Based on a synthesis of 25 studies, the review found that paths or trails, lighting, and, unexpectedly, incivilities were consistently associated with park-based physical activity. Referring to the conceptual model of Bedimo-Rung et al. (2005), as shown in Figure 2, these three attributes align with the categories of features, conditions, and safety.

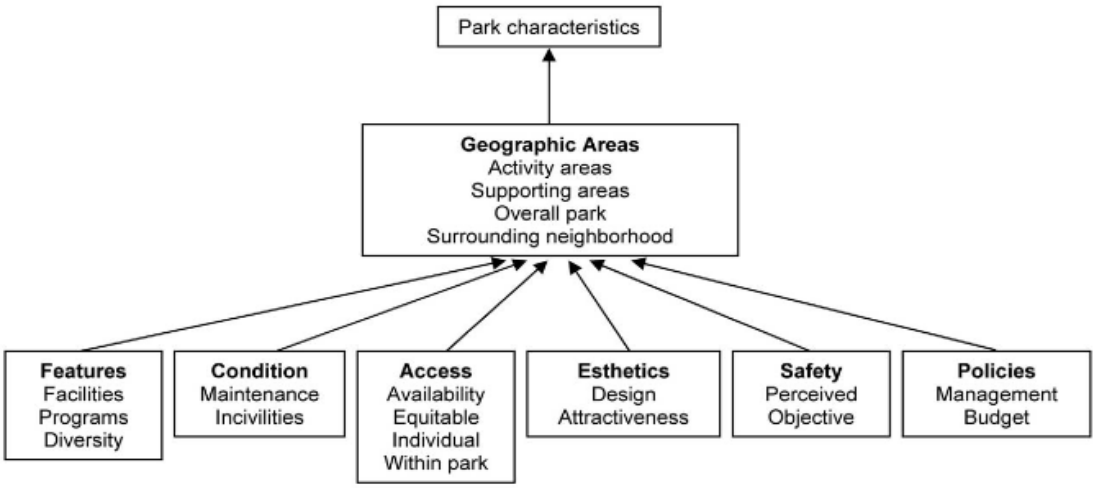

Figure 2 Environmental classification of park attributes.
(Bedimo-Rung et al., 2005)

Proximity to the park was not found to be significantly associated with park use and park-based PA (Kaczynski et al., 2014; Zhang et al., 2019). In contrast, several studies reported a positive association between park proximity and physical activity in parks (Padial-Ruz et al., 2021; Pietilä et al., 2015;

Cohen et al., 2007). Cohen et al. (2007) further recommended that parks be located within one mile of residential areas to increase availability and accessibility, which may help increase park use.

UGS features may include built environments and facilities such as courts, playgrounds, walking trails, outdoor gyms, fields, picnic areas, and shelters. Natural elements may involve tree cover, greenery, and water features such as lakes or ponds. Bedimo-Rung et al. (2005) encouraged future research to explore how these specific features, particularly physical components, relate to promoting park-based physical activity and leisure. The findings of Kaczynski et al. (2014) support this by showing that the built environment and available facilities were associated with increased park use and park-based activity. Smith et al. (2017) similarly found that built environment improvements—such as walkable spaces, playground equipment, and infrastructure for active transport—significantly positively affected park use and physical activity.

In contrast, Zhang et al. (2019) reported inconsistent results regarding the influence of park features on activity levels. A systematic review on outdoor gyms and exercise equipment commonly found in public parks also yielded mixed findings (Jansson et al., 2019). Koohsari et al. (2015) proposed that further research should investigate the role of specific features in supporting physical activity.

Koohsari et al. (2015) described three ways public open spaces may influence physical activity. First, they serve as venues for engaging in activity. Second, they function as destinations. Third, they provide routes that connect individuals to other destinations. These roles are shaped by geographic context. Park activity zones, in particular, are often designed to accommodate specific types of movement (Bedimo-Rung et al., 2005). A case study by McCormack et al. (2014) found that the physical attributes of parks influence patterns of park activity. Walking and dog-related activities were reported as the most frequent, while other activities observed included cycling, play, and sedentary behavior.

Multiple studies have also analyzed the intensity of physical activity within UGS. A systematic review of observational research found that users engaged in various activity levels, including sedentary, moderate, and vigorous (Joseph & Maddock, 2016). A study in Hong Kong observed that over 60 percent of park visitors participated in moderate or vigorous activity (Chow et al., 2016). A separate study by Chomitz et al. (2011) examined whether recreational spaces such as parks supported children in meeting recommended activity levels. Their findings showed that certain park features were significantly associated with meeting intensity targets.

2.5. User Sociodemographic of Urban Green Spaces

Individuals from diverse socio-demographic backgrounds have been observed using public urban green spaces (UGS). Characteristics of these areas contribute to different types and levels of physical activity across age groups, genders, and income levels (Koohsari et al., 2015). Trends in usage and gender distribution reveal that more males were observed than females (Chow et al., 2016; Chomitz et al., 2011; Cohen et al., 2007; Zhai et al., 2020; McCormack et al., 2014; Camargo Lemos et al., 2018). Among adults, males were more likely to engage in vigorous activity and use sports facilities, while females tended to use fitness stations, shelters, open spaces, and playgrounds where they supervised children (Chow et al., 2016; Cohen et al., 2007). Among children, boys were reported to be more independently mobile and physically active, while girls more often engaged in daily outdoor play and used active transport (Chomitz et al., 2011). In contrast, Joseph and Maddock (2016) found that the overall number of male and female users was nearly equal. Their review also noted that male-dominated usage patterns were mostly reported in studies conducted in the United States. Meanwhile, Kaczynski et al. (2014) observed more female than male users in their study.

Concerning age, adults were the most frequently observed users of parks, followed by seniors, children, and adolescents (Chow et al., 2016; McCormack et al., 2014). However, Joseph and Maddock (2016) found mixed outcomes in their review. While most studies showed a higher presence

of adults, a few reported comparable or higher proportions of children. Among age groups, older adults consistently had the least observed use of UGS. Padial-Ruz et al. (2021) noted that children benefit most from unstructured, spontaneous play, which is better supported by traditional playgrounds rather than structured programs. Dunton et al. (2020) observed an increased preference for unstructured play, such as biking, scootering, and roller skating among children during the COVID-19 pandemic. Kaczynski et al. (2014) found that different park features appeal to different age groups, emphasizing the importance of inclusive design to support park use across generations. A study focused on senior citizens found that they primarily engaged in walking and that outdoor fitness equipment could support broader participation (Zhai et al., 2020). Cohen et al. (2007) recommended developing tailored programs, incentives, and senior centers to promote park use among older adults.

2.6. Urban Green Spaces and Physical Activity in the Philippines

In the Philippines, 39.7 percent of the population was physically inactive in 2016 (Yeung & Johnston, 2019). WHO (2022b) later reported that the prevalence of physical inactivity in 2022 reached 93.5 percent among adolescents, 39.5 percent among adults, and 54.5 percent among older adults. Public green spaces in urban areas may help address this issue by providing accessible places for physical activity. A study by Saloma and Akpedonu (2021) identified various forms of activity in two Philippine parks. Rizal Park users were mostly observed resting, relaxing, or exercising along paths. The park was also used for socializing and school-related activities due to its proximity to educational institutions.

In contrast, users of the UP Academic Oval tended to engage in solo activities such as biking, jogging, running, or walking. These visitors also used the space for quiet thinking and reflection. Both parks were frequently used by individuals from low- and middle-income backgrounds, including homeless individuals, informal workers, students, professors, and other residents.

Within the national context, Shih (2016) emphasized the need to better understand public park use and its users to inform future design efforts. Gonzales and Magnaye (2016) argued that a successful UGS should accommodate a variety of recreational and cultural activities. Although urban planning in Metro Manila faces challenges, Saloma and Akpedonu (2021) observed that informal or unplanned public parks still serve important social interaction, exercise, leisure, and recreation functions. However, increasing urbanization and competing land uses may hinder the growth of UGS and limit its potential for supporting physical activity.

Marikina City, located in the National Capital Region of the Philippines, consists of two districts and sixteen barangays, with a recorded population of 456,059 in 2020 (Philippine Statistics Authority, 2020). The city was recognized as one of the healthiest in Asia by WHO and the Alliance for Healthy Cities in the early 2000s (Mercadero, 2021). It also received an award as one of the Most Improved Local Government Units in Environmental Health Services in 2021 from the Department of Health, WHO, and UNICEF (Marikina City Government, 2023b). As part of the Healthy Cities initiative, Marikina has implemented projects such as Bicycle-Friendly City, Healthy Tourist Park, and Urban River Rehabilitation (Sari et al., 2022). The city has 995,400 square meters of parks and open spaces, including the Marikina River, 13 pocket gardens, and 96 developed green areas (Marikina City Government, 2023a). As an early model of healthy urban development in Metro Manila, Marikina references other cities seeking to adopt similar strategies (WHO, 2003).

3. METHODS

This study used a qualitative approach with an observational, cross-sectional research design. The System for Observation of Play and Recreation in Communities (SOPARC), developed by McKenzie et al. in 2006, was used to collect data through systematic observation, following the protocol of the

instrument (McKenzie et al., 2006a). Interviews with individuals responsible for developing and managing the selected urban green spaces (UGS) were conducted to gather information on the historical background of the parks. No additional data collection methods were employed to minimize potential limitations and reduce participant bias.

3.1. SOPARC Instrumentation and Protocol

The SOPARC tool collected data through systematic observation in recreational environments such as public parks (McKenzie et al., 2006b). It applies momentary time sampling techniques to conduct periodic scans of designated areas. Its strengths include a low burden on participants, efficient and cost-effective data collection, and flexibility for adaptation to different community settings and research goals (Evenson et al., 2016). For this study, the SOPARC tool was adapted to conduct systematic observation for data collection.

This tool was used to assess the physical features of the selected UGS and observe factors such as accessibility, usability, equipment, lighting, supervision, activity organization, and park usage. The tool also allowed for the collection of demographic information, including visitor age, gender, and race. Levels of physical activity, sedentary behavior, and types of activity observed during data collection were also recorded.

Only minimal modifications were made to the SOPARC protocol. Observers recorded the age and gender of park visitors to describe user demographics. Physical activity levels were categorized as sedentary, moderate, or vigorous based on the users' observed actions. All recreational and physical activities observed were documented, and the most common activity type was identified. Area observations and data from the path coding form were compiled into the SOPARC Observation Form.

3.2. Interview

Interviews are commonly used in qualitative research to collect detailed data (Jamshed, 2014). To obtain information about the historical context, goals, and purpose of the selected UGS, interviews were conducted with two officials from Marikina City involved in park development and maintenance. These individuals were Cecilia Cerrero, Acting Assistant Chief of the River Park Authority and Administrative Officer at the time of writing, and Architect Ralph Espinosa, Officer-in-Charge and Assistant Head of the Architectural Design Unit and the School Repair and Maintenance Office.

Engineer Cecilia Cerrero has worked at the River Park Authority for over four decades and has played a central role in managing the Marikina River and River Parks. Architect Ralph Espinosa led the redevelopment of Grotto Park, also known as Park 15, within the Marikina Heights Park Complex and contributed significantly to its overall design.

The interview was conducted before the observation period and was recorded with verbal consent. A semi-structured format was used, employing open-ended questions to allow for consistent inquiry while accommodating additional relevant responses. The discussion focused on the history of the parks, their primary purpose, and original objectives. Considerations related to physical activity and recreation in developing and managing the parks were also explored. Follow-up questions were asked when necessary to clarify or expand on interviewee responses.

3.3. Park Selection

Marikina City is divided into two districts and contains 16 barangays. Each district selected one public park, resulting in two parks being observed. Selection criteria included park size, proximity to public establishments, and popularity among residents.

3.3.1. District 1: Marikina River Park – Main Areas

Marikina River Park (MRP), shown in Figure 3, is a riverside recreational area that stretches from Barangay Malanday to Barangay Barangka along the Marikina River. As part of the "Save the Marikina River" program, the area now includes pathways and trails used for walking, jogging, skating, cycling, and other recreational purposes. However, SOPARC is most effective in smaller, more defined areas (Evenson et al., 2016). During the observation period, the ChristmasSaya Bazaar occurred at the Marikina Skating/Biking Rink, and the Pasig-Marikina River Channel Improvement Project was underway near the riverside trails.

For this reason, observations were focused on the west bank of the river near Marikina Bridge. The observation area included the riverside road and the MRP Roman Garden, which contain the most features and receive high foot traffic due to their proximity to residential areas, restaurants, and the public market.

Figure 3 Maps of selected park areas – Marikina River Park

3.3.2. District 2: Marikina Heights Park Complex

The Marikina Heights Park Complex (MHPC), shown in Figure 4, is located in District 2, Barangay Marikina Heights. It includes Marikina Hardin ng Bayan (also known as Grotto Park or Park 15), the Marikina-Yeongdo Friendship Park (Evolution Park), and the Marikina-Brampton Friendship Park (Gazebo Park).

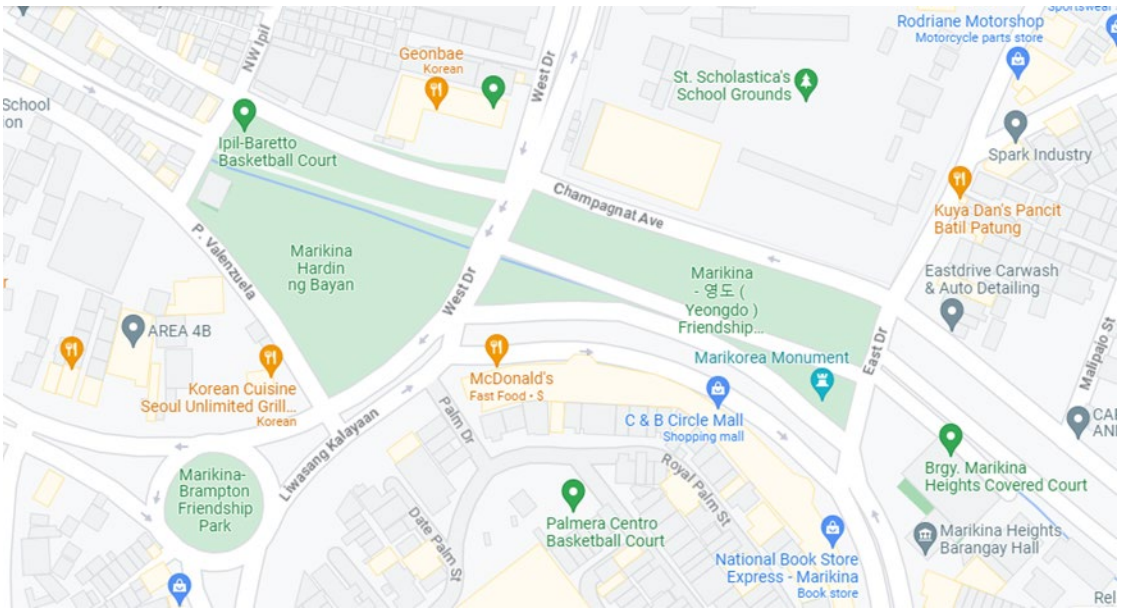

Figure 4 Maps of selected park areas – Marikina Heights Park Complex

The complex contains a wide range of park features. As with the Marikina River Park, this area experiences high visitor volume due to its location near residential neighborhoods, schools, malls, and restaurants.

3.4. Target Area Selection

Relevant Target Areas (TA) were measured, assessed, and mapped during an initial assessment of the selected parks. These areas represent locations that support physical activity (PA), leisure, and recreation among park visitors. The following target areas and sub-target areas were identified for observation:

1) Marikina River Park
    a) Target Area 1: Riverside Road
    b) Target Area 2: Roman Garden
    c) Target Area 3: Roman Garden Gazebo
2) Marikina Heights Park Complex
    a) Target Area 1: Gazebo Park
        i) The open area around the gazebo
        ii) Gazebo
        iii) Adjacent open areas
    b) Target Area 2: Grotto Park – Picnic Area
        i) Main Picnic Area
        ii) Picnic Area (Creekside)
    c) Target Area 3: Grotto Park – Playground
    d) Target Area 4: Evolution Park – Creekside

3.5. Observation Schedule and Protocol

This study followed the observation protocol outlined in the SOPARC Description and Procedures Manual (McKenzie et al., 2006a). Multiple SOPARC-based studies use a schedule of four days per week and four-time slots per day (morning, lunchtime, afternoon, and evening), as recommended by Evenson et al. (2016). This study adopted the same schedule for each selected UGS, observing Tuesdays and Thursdays (weekdays), Saturdays and Sundays (weekends). Observations occurred during the last week of November and the first week of December, which falls within the rainy season in the Philippines.

An initial assessment was also conducted to describe the parks' characteristics. This assessment focused on identifying each park's location, geography, natural and built environments, and visible improvements.

A customized, color-coded counter application called Counter: Click Counter App, developed by UXAPPS LTD, was used to count park visitors and physical activity occurrences. The resulting counts were entered into a digitized SOPARC coding form. The data were used to describe the characteristics of each park, including demographic distribution and types of physical activity. Summary counts described participant numbers according to demographic characteristics and activity levels.

3.6. Data Processing and Analysis

The recorded interviews were transcribed and summarized in alignment with the research objectives. Additional information, including relevant documents provided by interviewees, was also collected.

Observational data were organized and analyzed using descriptive statistics. The analytical approach followed the exploratory design by McKenzie et al. (2006b). User demographics and physical activity levels were described through frequency distributions, including the number of male and female users, different age groups, activity levels, and types of physical activity observed during various times of the day.

The unit of analysis was one scan of each target area to analyze park characteristics. A summary of physical structures, amenities, and facilities within each target area was provided. Physical activity observed in these areas was described in relation to the physical elements present. Additionally, the study explored whether specific demographic groups were present and active in areas with certain physical features.

4. RESULTS AND DISCUSSION

4.1. Historical Background, Location, and Geography of Selected UGS

Marikina City occupies a land area of 23.14 square kilometers, which includes the Marikina River that runs through the city. Approximately 4.3 percent of the city, or 995,400 square meters, comprises parks and open spaces. Among these, 96 parks and open spaces have been improved and developed. Since the early 2000s, the city has implemented Healthy City initiatives, including the Healthy Tourist Park, Bicycle-Friendly City, and Jogging Lanes programs. Marikina was named by the World Health Organization (WHO) as one of Asia's healthiest cities (WHO, 2003; Mercadero, 2021; Sari et al., 2022).

More recently, Marikina received awards for its public health programs and universal healthcare reforms between 2017 and 2022. Notably, in 2021, the city was recognized by the Association of Southeast Asian Nations as an Environmentally Sustainable City. During the evaluation, Marikina received a high score for the number of green spaces it offers, which surpasses the minimum requirement set by WHO for healthy urban living (Unite, 2021). Additionally, a study confirmed that Marikina meets the United Nations Development Programme indicators for a sustainable city and community (Javier et al., 2020).

These initiatives, awards, and recognitions suggest Marikina's continued commitment to developing as a healthy and sustainable city.

4.1.1. Marikina River Park

The entire Marikina River Park (MRP) is located on the elevated banks of the Marikina River, extending across 11 barangays. It is adjacent to commercial and government establishments, including Marikina City Hall, the public market, schools, restaurants, and shops. Residential areas are also situated along the riverbank. The park spans 22 kilometers and features attractions such as the Roman Garden, Chinese Pagoda, and trails for biking and jogging. Trees and vegetation are distributed throughout the park.

There are 21 access points in various barangays, allowing access by both pedestrians and vehicles. Footbridges inspired by military pontoon bridges enable people to cross the river from one side to the other.

In an interview, Acting Assistant Chief Cecilia Cerrero shared that the MRP was first developed in the 1970s. At the time, informal settlers lived along the river, which contributed to pollution and improper waste disposal. Then-Mayor Bayani "BF" Fernando enacted an ordinance designating a 96-

meter riverbank easement as government property and facilitated the relocation of these settlers. This initiative marked the beginning of the river's rehabilitation, which formally began in 1992. Access roads and paths were constructed, followed by the development of pocket parks and the installation of park features donated by various organizations. Examples include the Roman Garden Gazebo from the Jesuits and the Chinese Pagoda from the Marikina Chinese Chamber.

According to Engr. Cerrero, Mayor Fernando envisioned the park as a place "for the people to touch and feel the water." She outlined three goals of the park's development: (1) to promote environmental appreciation and stewardship among citizens and local government, especially for the river and its surroundings; (2) to provide open space for community development; and (3) to establish areas for recreation and sports. Recreational features throughout the river park include the Roman Garden, Chinese Garden, trails for jogging and cycling, and basketball courts distributed across barangays connected by the park.

Development and maintenance of the MRP continue annually through the River and River Parks Rehabilitation Program. At the time of this study, the Department of Public Works and Highways was implementing the Pasig-Marikina River Channel Improvement Project, which aims to expand the river's holding capacity to reduce flood risk and improve the park's sustainability.

4.1.2. Marikina Heights Park Complex

The Marikina Heights Park Complex (MHPC), located along West Drive and Liwasang Kalayaan Streets in Barangay Marikina Heights, District II, includes three pocket parks: Marikina Hardin ng Bayan (Grotto Park or Park 15), the Marikina-Yeongdo Friendship Park (Evolution Park), and the Marikina-Brampton Friendship Park (Gazebo Park). Grotto Park is the largest, with a total area of 8,662 square meters. The park complex is surrounded by residential areas, schools, shops, the Marikina Heights Barangay Hall, two commercial malls, and public transport terminals, all within a ten-minute walking distance. The three parks feature exercise equipment, playgrounds, and picnic areas.

Architect Ralph Espinosa explained that before its 2019 redevelopment, Park 15 was primarily a grotto area surrounded by trees and vegetation, with a few cement benches and pathways. He described it as a space that was not conducive to active use. During the interview and in the project brief, he stated two main objectives for the redevelopment: (1) to create a functional space for the community to enjoy and (2) to create a healthy and aesthetically pleasing environment combining natural and built elements.

He also described the design goals: (1) to improve the park as a safe, accessible, and sustainable space for gathering, health, recreation, and worship, and (2) to connect it with nearby open spaces, commercial centers, and schools. The park's primary users include the 24,487 nearby residents and approximately 48,974 daily commuters, especially children, youth, older adults, people with disabilities, and visitors.

Design elements were intended to support these goals. All 152 existing trees were preserved, lighting and rest areas were added, and multiple pathways were constructed to enhance access. Built features include a playground, exercise stations, and nearby basketball courts. Park tables, benches, and mushroom-shaped trellis seats provide space for rest, meals, and gatherings. Permeable pavements were installed to reduce surface water retention. Rubber granules were applied to surfaces near the grotto and playground to improve safety and comfort. Pathways also function as routes for walking, jogging, and cycling.

The MHPC improves connectivity between schools, commercial areas, and public spaces. According to Ar. Espinosa, the park provides a place for people to bring food from nearby shops, for students to visit after school, and for residents to hold gatherings. He also noted that the development supports the local economy. Moreover, he highlighted the importance of open space following the pandemic.

The redevelopment of the MHPC gives people a chance to leave their homes and enjoy public green space

4.1.3. Discussion

Based on the interview, both parks were previously undeveloped spaces. The Marikina River Park, in particular, suffered from pollution caused by informal settlements and poor waste management. This issue is still being addressed today, as informal settlements remain challenging in Marikina's urban planning and often obstruct development projects (Saloma & Akpedonu, 2021). The local government saw potential in these spaces and initiated their rehabilitation through programs such as the Urban River Rehabilitation Program and the Green Green Green – Marikina City Park 15 Redevelopment Project.

The identified objectives of these parks align with the human needs outlined by Saloma and Akpedonu (2021), particularly within urban planning. These needs include access to nature, opportunities for personal development through physical activity, and creating community-oriented spaces. Such needs have become especially urgent in the aftermath of the COVID-19 pandemic. As Architect Espinosa noted, the redevelopment of Marikina Heights Park was given renewed importance due to its ability to support community well-being during lockdowns. Sari et al. (2022) emphasized the role of the urban environment in fostering resilient community management and post-pandemic recovery. MRP and MHPC contribute to the physical and social resilience of the city and its residents, especially during public health crises.

4.2. Physical Structures, Facilities, and Amenities of Selected UGS

The Marikina River Park (MRP) observation area consists of three target areas (TAs): the Riverside Road, the Roman Garden, and the Roman Garden Gazebo.

Table 1 Marikina River Park Mapping Variables and Park Characteristics

Target Areas	TA 1: Riverside Road	TA 2: Roman Garden	TA 3: Roman Garden Gazebo
Setting	Outdoor	Outdoor	Outdoor, Shelter
Natural Environment	Tree Cover, River	Tree Cover	None
Area Type	Road	Picnic Area	Multipurpose
Area Improvements			
	Lighting (dim) Cement Road Basketball Hops Comfort Rooms – Male & Female Footbridge Parking Bike Rentals* Vendors/Kiosk*	Lighting (well-lit) Benches Tables Fountain (unused)	Lighting (well-lit)
Improvement Overlap	Yes	No	No
Surface Flooring			
Primary	Cement	Grass/soil	Cement
Secondary	Grass/Soil	Cement	-
Others	-	-	-

**not permanent – may move around or close at certain times*

Target Area 1 includes Riverside Road, which extends from beneath Marikina Bridge to one of the entrances of the Roman Garden. This area is an access point to the river and is accessible to vehicles, bicycles, and pedestrians. It features a parking area, a basketball hoop, a bike rental shop, and several vendors and kiosks. The road's width allows for multiple simultaneous activities despite overlapping spatial uses. Lampposts provide adequate lighting for nighttime activities.

Target Area 2, the Roman Garden, includes a non-functional fountain, a set of tables and benches, and several mature trees that offer shade. Cement seating surrounds the fountain, and the area contains varying elevations. Target Area 3, the Roman Garden Gazebo, is situated within TA 2 and is elevated by a small staircase. Its high ceiling offers both shade and visual appeal. TA 2 and TA 3 are equipped with lighting that remains operational at night. Table 1 presents the mapping variables and park characteristics for each area.

Two additional areas were initially considered for inclusion: the skating/bicycle rink and the riverside bike and jogging trails. However, the trails were inaccessible due to the ongoing Pasig-Marikina River Channel Improvement Project. The skating/bicycle rink was also excluded from observation because it was used as the venue for the annual Christmas bazaar at the time of the study.

In District II of Marikina, the Marikina Heights Park Complex (MHPC) observation area includes four TAs: Gazebo Park, Grotto Park – Picnic Area, Grotto Park – Playground, and Evolution Park. Table 2 provides an overview of the park improvements and characteristics for each area.

Table 2 Marikina Heights Park Complex Mapping Variables and Park Characteristics

Target Areas	**TA 1: Gazebo Park**	**TA 2: Grotto Park – Picnic Area**	**TA 3: Grotto Park - Playground**	**TA 4: Evolution Park**
Setting	Outdoor	Outdoor	Outdoor	Outdoor
Natural Environment	Tree Cover	Tree Cover, Creek	Tree Cover	Tree Cover, Creek
Area Type	Multipurpose	Picnic Area	Play Space	Field
Area Improvements				
	Lighting (well-lit)	Lighting (well-lit)	Lighting (well-lit)	Lighting (dim)
	Mushroom Trellis Seating	Mushroom Trellis Seating	Mushroom Trellis Seating	Benches
	Gazebo	Picnic Tables & Chairs	Picnic Tables & Chairs	Cow Statues
		Pathways	Swing Set	Pathways
		Footbridge	Playground Set	Footbridge
		Grotto with Image of the Virgin Mary		Monkey Bars
		Candle Stand		Exercise Bars
		Bike Parking		Exercise Station
		Vendors/Kiosk*		Circular Cement Stage
Improvement Overlap	Yes	No	No	No
Surface Flooring				
Primary	Semi-permeable cement	Semi-permeable cement	Semi-permeable rubber granules	Grass
Secondary	Wood	Gravel	-	Cement
Others	Tile (Gazebo)	Soil (Trees)	-	Gravel

**not permanent – may move around or close at certain times*

All target areas in the MHPC are outdoors and have sufficient tree cover for shade. Only TA 1 features a gazebo that offers protection from sun and rain. Lighting was generally adequate, though part of TA 4 was less illuminated. Seating options such as mushroom trellis benches, picnic tables, and cement seating are distributed across all TAs.

TA 2 consists of multiple functional areas, including picnic zones, resting spots, and a space for worship. TA 3 contains a children's play area with slides, stairs, ladders, tunnels, a swing set, and interactive features. Seating is available nearby for parents or guardians. Architect Ralph Espinosa explained that rubber granules were used in this area to enhance safety during physical activity.

TA 4, known as Evolution Park, is a long stretch designed for physical activity. It features several improvements, including a pathway and historical markers such as cow statues that reference Marikina's past as grazing land in the 1800s. According to Ar. Espinosa, this area was intended to highlight the city's historical transformation. The pathway in TA 4 connects to TA 2 and leads to a nearby commercial mall. Unlike the other areas, TA 4 has grass, cement, and gravel flooring, which may result in muddy patches and water accumulation during rain.

The accessibility, usability, and overall conditions of both parks during the observation period are summarized in Table 3.

Table 3 Park Characteristics during Observation of Selected Urban Green Spaces

N=16 visits	**Marikina Heights Park Complex**				**Marikina River Park**		
	TA 1	**TA 2**	**TA 3**	**TA 4**	**TA 1**	**TA 2**	**TA 3**
Accessible? (%)	93.75	100	100	100	100	100	100
Usable? (%)	100	100	93.75	87.5	100	100	100
Supervised? (%)	25	0	0	6.25	25	6.25	6.25
Equipped? (%)	0	0	0	0	0	0	0
Organized? (%)	25	0	0	6.25	6.25	6.25	0
Dark? (%)	0	0	0	0	0	0	6.25
Empty? (%)	0	0	6.25	0	0	0	18.75

The table shows that most target areas in both UGS were accessible, usable, unequipped, and well-lit during the observation period. Inaccessibility or unusability occurred when areas were used for events or affected by rain, which deterred physical activity. In some cases, these areas were observed to be unoccupied.

Supervised and organized physical activities were recorded in MHPC, including Zumba sessions in TA 1 and Taekwondo classes in TA 1 and TA 4. Park cleaners were present in both locations, and the River Park Authority security personnel were seen in MRP. While some areas were dimly lit, all were lit at night, except for TA 3 (Roman Garden Gazebo in MRP), which was dark and also unoccupied during that time.

Bedimo-Rung et al. (2005) identified access, aesthetics, condition, and safety as core attributes that support park-based physical activity and recreation. The observations reported in Table 3 indicate that both MRP and MHPC are generally accessible, usable, and adequately lit. The presence of security personnel and park cleaners suggests a well-maintained and monitored environment, which may contribute to a higher perception of safety. Notably, the one dimly lit area was unoccupied, which may reflect a behavioral response to perceived safety concerns.

4.3. Demographic of Park Visitors in Selected UGS

Table 4 summarizes the demographic distribution of visitors in each park, shown as a proportion of the total visitors observed in both urban green spaces (UGS).

Table 4 Summary of the Demographic of Park Visitors by Park

Total Count	Marikina Heights Park Complex		Marikina River Park		Total	
	Total	%(n)	Total	%(n)	Total	%(n)
Total Users (n=6948)	3908	56.25	3040	43.75	6948	100
	Total	%(n=3908)	Total	%(n=3040)	Total	%(n=6948)
By Gender						
Female	1938	49.59	1359	44.7	3297	47.45
Male	1970	50.41	1681	55.3	3651	52.55
By Age						
Children	557	14.25	389	12.8	946	13.62
Teenager	1829	46.8	1633	53.72	3462	49.83
Adult	1414	36.18	897	29.51	2311	33.26
Elder;y	108	2.76	121	3.98	229	3.3
Week Period						
Weekday	2118	54.2	1358	44.67	3476	50.03
Weekend	1790	45.8	1682	55.33	3472	49.97

During the observation period, a total of 6,948 visitors were recorded. Of these, 3,908 (56.25%) were observed in the Marikina Heights Park Complex (MHPC), while 3,040 (43.75%) were in the Marikina River Park (MRP). Although the MRP is considered a landmark and tourist destination in Marikina City, it received fewer visitors than the recently redeveloped MHPC. This may be attributed to the smaller area observed in MRP and the presence of more organized activities in MHPC, such as Zumba and taekwondo sessions. The newly improved conditions of the MHPC, including its built environment and ongoing activities, may also have contributed to its higher visitor numbers.

In both parks, male visitors comprised the majority at 52.55%, while female visitors accounted for 47.45%. These findings align with previous studies reporting a higher number of male users in urban green spaces (Chow et al., 2016; Chomitz et al., 2011; Cohen et al., 2007; Zhai et al., 2020; McCormack et al., 2014; Camargo Lemos et al., 2018).

The age distribution of visitors varied across parks. Teenagers represented the largest group at 49.83%, followed by adults (33.26%), children (13.62%), and the elderly (3.3%). These findings differ from earlier studies that reported more adults than younger age groups (Chow et al., 2016; McCormack et al., 2014; Joseph & Maddock, 2016) or studies that observed a majority of children (Joseph & Maddock, 2016; Cohen et al., 2007). These differences may reflect the influence of specific park features that appeal to particular age groups (Kaczynski et al., 2014). For instance, Architect Ralph Espinosa stated that the MHPC redevelopment aimed to attract more elderly and child visitors. However, only TA 3 (with a playground) and TA 4 (with a senior exercise station) specifically addressed these demographics. The limited improvements for children and elderly visitors in both parks may explain their relatively low turnout.

Visitor numbers were slightly higher on weekdays (50.03%) than weekends. However, more visitors were observed in the MRP on weekends (55.33%). This may relate to rainfall during the Sunday observation for MHPC, which corresponds with findings from Van Dyck et al. (2013) that showed fewer park users during rainy weather.

Table 5 presents the demographic breakdown of visitors by time of day, disaggregated by gender and age group across both parks.

Table 5 Demographic of Park Visitors by Time in Selected UGS

			Marikina Heights Park Complex					Marikina River Park					Total
			7:30 AM	11:30 AM	3:30 Am	6:30 AM	Total	7:30 AM	11:30 AM	3:30 AM	6:30 AM	Total	
Gender	Female	Total	340	525	687	386	1938	142	313	604	300	1359	3297
		%	50.52	54.80	49.67	43.18	49.59	35.06	50.81	48.17	39.22	44.70	47.45
	Male	Total	333	433	696	508	1970	263	303	650	465	1681	3651
		%	49.48	45.20	50.33	56.82	50.41	64.94	49.19	51.83	60.78	55.30	52.55
Age Group	Children	Total	91	106	228	132	557	72	26	165	126	389	946
		%	13.52	11.06	16.49	14.77	14.25	17.78	4.22	13.16	16.47	12.80	13.62
	Teen	Total	60	597	784	388	1829	66	481	770	316	1633	3462
		%	8.92	62.32	56.69	43.40	46.80	16.30	78.08	61.40	41.31	53.72	49.83
	Adult	Total	468	236	355	355	1414	219	102	282	294	897	2311
		%	69.54	24.63	25.67	39.71	36.18	54.07	16.56	22.49	38.43	29.51	33.26
	Elderly	Total	54	19	16	19	108	48	7	37	29	121	229
		%	8.02	1.98	1.16	2.13	2.76	11.85	1.14	2.95	3.79	3.98	3.30
	Total		673	958	1383	894	3908	405	616	1254	765	3040	6948
	%		17.22	24.51	35.39	22.88	56.25	13.32	20.26	41.25	25.16	43.75	100.00

The 3:30 PM observation period recorded the highest number of visitors in both the MHPC (35.39%) and the MRP (41.25%), while the 7:30 AM period recorded the fewest (17.22% for MHPC and 13.32% for MRP). These findings contrast with those of Chow et al. (2016), who reported fewer visitors during late morning and afternoon than in early morning.

The dominant demographic varied across different time periods. Philippine school hours typically begin at 7:00 or 8:00 AM and end between 12:00 NN and 5:00 PM, depending on the schedule. Most adult visitors were observed at 7:30 AM, a time that falls outside regular working hours. In contrast, most teenage and child visitors arrived at 3:30 PM and 6:30 PM, following the end of school hours. Given the parks' proximity to multiple schools, many students appear to visit these UGS after classes. This pattern supports the role of urban green spaces in promoting connectivity within communities and between schools, commercial establishments, and public spaces. Similarly, the high number of adults observed at 7:30 AM in MHPC and 6:30 PM in MRP reflects visitation outside regular work hours. Table 6 shows the number of park visitors recorded in each target area across both UGS.

Table 6 Park Visitor by Target Area in Selected UGS

Target Areas	Marikina River Park		Marikina Heights Park Complex	
	Total	% (3908)	Total	% (3040)
TA 1	738	18.88	2102	69.14
TA 2	2375	60.77	541	17.80
TA 3	385	9.85	394	13.06
TA 4	410	10.49	-	-

The largest largest target areas in each park—TA 2 in MHPC and TA 1 in MRP, received the highest number of visitors, accounting for 60.99% and 69.14% of total park users, respectively. These areas contain the most significant physical improvements and features.

In contrast, TA 3 (Roman Garden Gazebo) of the MRP recorded the lowest visitor count and was observed to be empty during the 7:30 AM period on three separate days. Despite being accessible and usable throughout the observation period, this area only accounted for 13.06% of the total MRP visitors. This may be due to the limited features within this area. Similarly, TA 3 (Playground) in the MHPC was the least visited area in that park. While it is specifically designed for children's play and includes multiple built features, its low visitation rate suggests that children comprised a smaller portion of overall park users during the observation period.

4.4. Physical Activity of Park Visitors in the Selected UGS

4.4.1. Physical Activity Intensity Level of the Park Visitors

Table 7 presents park visitors' physical activity (PA) intensity levels in each target area of the selected urban green spaces (UGS).

Table 7 Physical Activity Intensity Level of Park Visitors by Target Areas in Selected UGS

Park Users' Activity Level		Marikina Heights Park Complex					Marikina River Park				Total (6948)
		TA 1	TA 2	TA 3	TA 4	Total	TA 1	TA 2	TA 3	Total	
Sedentary	Total	335	1563	79	158	2135	617	307	300	1224	3359
	%	45.39	65.81	20.52	38.54	54.63	29.35	56.75	75.57	40.26	48.34
Moderate	Total	385	806	270	198	1659	1343	234	93	1670	3329
	%	52.17	33.94	70.13	48.29	42.45	63.89	43.25	23.43	54.93	47.91
Vigorous	Total	18	6	36	54	114	142	0	4	146	260
	%	2.44	0.25	9.35	13.17	2.92	6.76	0.00	1.01	4.80	3.74
TOTAL		738	2375	385	410	3908	2102	541	397	3040	6948

The majority of park visitors were observed engaging in some form of physical activity during the observation period. While 48.34% were engaged in sedentary behavior, 47.91% participated in moderate-intensity activity, and 3.74% in vigorous-intensity activity. Thus, 51.66% of visitors were physically active at the time of observation.

Previous studies have shown mixed findings regarding the distribution of PA intensity levels. For instance, Chow et al. (2016) reported that 52.3% of park users were vigorously active, whereas Cohen

et al. (2007) found that most visitors were sedentary. A systematic review by Evenson et al. (2016) supports this inconsistency, suggesting that such variation may stem from differing definitions of sedentary behavior and the limitations of tools that only capture activity at a single moment.

Sedentary behaviors were most prevalent in TA 2 of the MHPC and TA 2 and 3 of the MRP. These areas, categorized as picnic or multipurpose zones, were designed primarily for rest and social interaction. Common sedentary behaviors included resting, socializing, and eating. Some visitors were observed sitting while doing crafts, praying, fishing by the river, reciting poetry (sabayang pagbigkas), or playing while seated. The availability of benches, tables, and nearby food vendors supports such activities.

The parks' purpose of fostering community interaction is reflected in these observations. Many visitors came in groups, families, classmates, or school clubs such as the Marikina Chess Club, which held regular games in the MHPC.

Referring to Table 7, moderate-intensity PA was more common in most target areas. In particular, TA 3 and 4 of the MHPC and TA 1 of the MRP featured playground equipment, exercise stations, and sports-related infrastructure, such as basketball hoops, which encourage PA. These observations align with previous studies highlighting the importance of the built environment in facilitating physical activity (Smith et al., 2017; Koohsari et al., 2015; Bedimo-Rung et al., 2005; McCormack et al., 2014).

Wide-open spaces also supported unstructured activities such as dancing, running, and playing, especially when visitors brought their equipment like balls or rackets. A diverse range of park features helps accommodate a broad spectrum of visitors' physical activity needs.

Table 8 PA of Park Visitors by Gender at Specific Target Areas in Selected UGS

Park Users' Activity Level			Marikina Heights Park Complex					Marikina River Park				Total (6908)
			TA 1	TA 2	TA 3	TA 4	Total	TA 1	TA 2	TA 3	Total	
Male	Sedentary	Total	167	767	30	116	1080	359	167	122	648	1728
		%	54.75	64.67	15.79	40.14	54.82	28.74	57.49	86.52	38.55	24.87
	Moderate	Total	127	214	139	126	805	756	124	19	899	1704
		%	41.64	34.82	73.16	43.60	40.86	60.53	42.61	13.48	53.48	24.53
	Vigorous	Total	11	6	21	47	85	134	0	0	134	219
		%	3.61	0.51	11.05	16.26	4.31	10.73	0.00	0.00	7.97	3.15
	Total		305	1186	190	289	1970	1249	291	141	1681	3651
Female	Sedentary	Total	168	796	49	42	1055	258	140	178	576	1631
		%	38.80	66.95	25.13	34.71	54.44	30.25	56.00	69.53	42.38	23.47
	Moderate	Total	258	393	131	72	854	587	110	74	771	1625
		%	59.58	33.05	67.18	59.50	44.07	68.82	44.00	28.91	56.73	23.39
	Vigorous	Total	7	0	15	7	29	8	0	4	12	41
		%	1.62	0.00	7.69	5.79	1.50	0.94	0.00	1.56	0.88	0.59
	Total		433	1189	195	121	1938	853	250	256	1359	3297

Vigorous PA was relatively rare (3.74%). Most of this occurred in TA 4 of the MHPC through calisthenics and in TA 1 of the MRP through biking, jogging, and rope jumping. These activities were

strongly associated with the presence of supportive infrastructure. Table 8 details the distribution of park-based physical activity across gender groups within each target area.

Among all 6,948 visitors, the largest group was males engaging in sedentary behavior (24.87%), followed closely by males in moderate PA (24.53%). Female visitors in sedentary and moderate PA followed at 23.47% and 23.39%, respectively. Males dominated the vigorous PA group (3.15%), while only 0.59% of female visitors were observed performing vigorous PA.

Moderate to vigorous activity was mostly observed among male visitors. TA 4 (Evolution Park) in the MHPC and TA 1 (Riverside Road) in the MRP were primarily visited by males, who comprised 70.49% and 59.42% of the respective populations. Features such as open roads, basketball hoops, and exercise bars may explain this demographic skew, as males largely performed calisthenics and biking. These findings align with existing literature that reports men's greater use of sport-related facilities (Cohen et al., 2010; Chow et al., 2016).

Conversely, females were more frequently observed in TA 1 and 2 of the MHPC and TA 3 of the MRP. In TA 1 of the MHPC, many female adults and the elderly participated in organized Zumba classes. In TA 3 (Playground), women were mostly seen supervising or playing with children. These observations confirm that females use playgrounds, fitness stations, and open spaces (Cohen et al., 2007; Cohen et al., 2010; Chow et al., 2016). Table 9 presents the intensity of physical activity across different age groups in each target area.

Table 9 PA of park visitors by Age at Specific Target Areas in Selected UGS

Park Users' Activity Level			Marikina Heights Park Complex					Marikina River Park				Total (6908)
			TA 1	TA 2	TA 3	TA 4	Total	TA 1	TA 2	TA 3	Total	
Child	Sedentary	Total	10	100	11	20	141	109	22	0	131	272
		%	38.46	52.63	4.26	24.10	25.31	31.05	64.71	0.00	33.68	3.91
	Moderate	Total	3	85	211	43	342	229	12	0	241	583
		%	11.54	44.74	81.78	51.81	61.4	65.24	35.29	0.00	61.95	8.39
	Vigorous	Total	13	5	36	20	74	13	0	4	17	91
		%	50.00	2.63	13.95	24.1	13.29	3.7	0.00	100.00	4.37	1.31
	Total		26	190	258	83	557	351	34	4	389	946
Teen	Sedentary	Total	267	690	6	58	1021	202	168	259	629	1650
		%	52.35	58.08	46.15	49.15	55.82	21.58	47.46	75.51	38.52	23.75
	Moderate	Total	242	498	7	39	786	661	186	84	931	1717
		%	47.45	41.92	53.85	33.05	42.97	70.62	52.54	24.49	57.01	24.71
	Vigorous	Total	1	0	0	21	22	73	0	0	73	95
		%	0.20	0.00	0.00	I 7.80	1.20	7.80	0.00	0.00	4.47	1.37
	Total			510	1188	13	118	1829	936	354	343	1633
Adult	Sedentary	Total	58	711	62	77	908	276	108	34	418	1326
		%	32.04	77.11	54.87	38.89	64.21	38.71	75.00	85.00	46.60	19.08
	Moderate	Total	119	210	51	108	488	388	36	6	430	918
		%	65.75	22.78	45.13	54.55	34.51	54.42	25.00	15.00	47.94	13.21
	Vigorous	Total	4	1	0	13	18	49	0	0	49	67
		%	2.21	0.11	0.00	6.57	1.27	6.87	0.00	0.00	5.46	0.96
	Total		181	922	113	198	1414	713	144	40	897	2311.00
Elderly	Sedentary	Total	0	62	0	3	65	30	9	7	46	111
		%	0.00	82.67	0.00	27.27	60.19	29.41	100.00	70.00	38.02	1.60
	Moderate	Total	21	13	1	8	43	65	0	3	68	111
		%	100.00	17.33	100.00	72.73	39.81	63.73	0.00	30.00	56.20	1.60
	Vigorous	Total	0	0	0	0	0	7	0	0	7	7
		%	0.00	0.00	0.00	0.00	0.00	6.86	0.00	0.00	5.79	0.10
	Total		21	75	1	11	108	102	9	10	121	229

The majority of active park users were teenagers participating in moderate PA (24.71%), followed by teenagers in sedentary behavior (23.75%) and adults in sedentary behavior (19.08%). Children and adults participating in vigorous PA accounted for only 1.31% and 0.96%, respectively, while the elderly comprised just 0.10% of those in this activity category.

TA 3 (Playground) of the MHPC was the area most dominated by children (67.01%). Architect Ralph Espinosa designed this area specifically for children's use, incorporating features like rubberized flooring for safety. Similarly, TA 1 of the MRP had the highest number of child visitors in that park. Unstructured play, such as running games, use of playground equipment, and cycling, was common. Studies confirm that such environments are key to promoting children's PA (Padial-Ruz et al., 2021; Dunton et al., 2020).

In contrast, elderly park users were the least observed. This aligns with findings by Joseph & Maddock (2016), although Chow et al. (2016) reported different results in a Hong Kong study. While the elderly comprised only 3.3% of total visitors, their presence in TAs, such as TA 1 of both parks, was notable, especially in Zumba classes and while walking or biking. These activities reflect the importance of organized programs and accessible open roads for promoting elderly participation (Zhai et al., 2020; Levy-Storms et al., 2017; Cohen et al., 2011). Despite this, the senior-friendly exercise station in TA 4 of the MHPC attracted a few elderly users, suggesting potential for further improvement.

4.4.2. Types of Physical Activity of Park Visitors

Figure 5 and Figure 6 summarize the various types of physical activity (PA) observed in each target area (TA) of the Marikina River Park (MRP) and Marikina Heights Park Complex (MHPC), respectively. These tables indicate the corresponding intensity level of each activity, as classified by the CDC (2005), and show the frequency of each activity based on 16 observation sessions conducted per park.

Marikina River Park								
TA 1			**TA 2**			**TA 3**		
Activity Type	**Intensity**	***f***	**Activity Type**	**Intensity**	***f***	**Activity Type**	**Intensity**	***F***
Biking	Moderate to Vigorous	16	Walking	Moderate	10	Dancing	Moderate	2
Walking/ Dog-walking	Moderate	16	Dancing	Moderate	3	Warm-up Exercises	Moderate	1
Basketball	Moderate to Vigorous	11	Badminton	Moderate	3	Sabayang Pagbigkas Choreography	Moderate	1
Badminton	Moderate	5	Picking-up Trash	Moderate	1	Playing/ Running	Vigorous	1
Dancing	Moderate	4	Arnis	Moderate	1			
Warm-up Exercises	Moderate	1						
Picking-up trash	Moderate	1						
Kids Playing with Ball	Moderate	2						
Jogging	Vigorous	1						
Arnis	Moderate	1						
Skateboarding	Moderate	1						
Jump rope	Vigorous	1						

Figure 5 Types of Physical Activity in Each Target Area in the Marikina River Park

A total of 14 types of park-based PA were observed in the MRP. Five were classified as vigorous: biking, basketball, jogging, running/playing, and jump rope. Biking intensity varied from moderate (5–9 mph) to vigorous (>10 mph), though most bikers observed fell under moderate intensity. In the MHPC, 13 distinct PA types were recorded, with four considered vigorous: organized taekwondo, running/playing, calisthenics, and jump rope. Both basketball and calisthenics relied on specific built environments in their respective TAs. While biking was also observed in the MHPC, the park's layout restricted this to moderate intensity.

Walking and biking were the most frequently observed activities. Walking occurred in nearly every TA except TA 3 of the MRP, a compact circular space. It was most prevalent on the riverside road and in TAs with pathways such as TA 2 and TA 4 in the MHPC. Many walkers appeared to use the parks as a thoroughfare connecting neighborhoods and establishments. Biking was observed during all time slots in TA 1 of the MRP, where the road layout supports both recreation and commuting.

This aligns with prior studies identifying walking as a dominant park-based PA (McCormack et al., 2014; Joseph & Maddock, 2016). Walkability is a major factor in encouraging PA across age and gender groups (Ding et al., 2011; Zhang et al., 2019; Kaczynski et al., 2014; Smith et al., 2014; Chomitz et al., 2014; Koohsari et al., 2015; Chow et al., 2016). Trails and connecting paths foster walking and biking as active transportation (Smith et al., 2017). Additionally, bike rental availability in TA 1, featuring units for children, teens, and adults, enabled group biking activities for visitors without personal bikes.

Marikina Heights Park Complex Physical Activity Types											
TA 1			**TA 2**			**TA 3**			**TA 4**		
Activity Type	**Intensity**	***f***	**Activity Type**	**Intensity**	***f***	**Activity Type**	**Intensity**	***f***	**Activity Type**	**Intensity**	***f***
Zumba/ Dancing	Moderate	11	Walking/ Dog-walking	Moderate	16	Playing on Playground	Moderate	15	Walking	Moderate	15
Walking/ Dog-walking	Moderate	8	Dancing	Moderate	7	Playing/ Running	Vigorous	4	Exercise Equipment	Moderate	12
Volleyball	Moderate	2	Volleyball	Moderate	6	Walking	Moderate	1	Calisthenics	Vigorous	7
Biking	Moderate	2	Badminton	Moderate	6	Biking	Moderate	1	Badminton	Moderate	3
Taekwondo	Vigorous	2	Biking	Moderate	5				Biking	Moderate	2
			Arnis	Moderate	2				Warm-up Exercises	Moderate	1
			Playing/ Running	Vigorous	2				Taekwondo	Vigorous	1
			Warm-up Exercises	Moderate	1				Dancing	Moderate	1
			Jump rope	Vigorous	1				Playing/ Running	Vigorous	1

Figure 6 Types of Physical Activity in Each Target Area in the Marikina Heights Park Complex

Unexpectedly, dancing was commonly observed, especially in TA 1 and TA 2 of the MHPC. Though no park features were designed for this activity, dancing occurred in nearly every TA of both parks, except TA 3 of the MHPC, which is a children's playground. Dancing styles included ballroom, street dance, hip-hop, and folk. Most participants were high school or college students rehearsing for performances or school projects.

Other student-based activities were also observed, such as arnis (a Filipino martial art) and sabayang pagbigkas with choreography. These were typically educational and involved large groups of

teenagers. Non-PA student activities included group crafts, socializing, and poetry recitation. Although uncommon in international literature, these uses of UGS are consistent with local contexts. Saloma and Akpedonu (2021) found that students prefer using nearby public green spaces for school-related activities due to proximity and free access. MRP and MHPC are located near schools from elementary to college level, which likely explains their popularity among students for such uses.

Zumba was one of the few organized activities recorded. Most Zumba participants were female adults and elderly visitors. This type of dance-based exercise is known to be popular among women (Cugusi et al., 2019) and was observed to be particularly inclusive due to its easy steps and appeal across age groups. However, being a paid activity, youth participation was limited.

Another observed organized activity was taekwondo, which occurred several times in the MHPC. Most participants were children. While some literature discourages structured activities for children in favor of unstructured play (Padial-Ruz et al., 2021; Dunton et al., 2020), taekwondo classes successfully drew younger visitors to parts of the park that did not otherwise cater to their age group. These findings support the idea that organized programs can help fill gaps where park design lacks specific features for children (Cohen et al., 2010).

5. CONCLUSION

5.1. Limitation

While there is a wide range of spaces considered urban green spaces (UGS), this study focused exclusively on public parks that are free to access and open to the Filipino community. Only the characteristics and visitors of the selected urban public parks in Marikina City, Philippines, were considered. The study was conducted during the country's rainy season and was limited to a short data collection period. The cross-sectional observational design restricted data to a single point in time. Chow et al. (2016) observed that park user characteristics and physical activity (PA) patterns differ across seasons. Furthermore, certain park features may be inaccessible due to weather conditions or natural events, which may have affected the findings.

This study covered only two selected parks in Marikina City, despite the city having 96 developed parks with various programs to promote PA and expand UGS. Thus, the findings may not fully represent urbanized areas with limited green spaces or outdoor PA access. The difference in the size of the selected areas must also be acknowledged. The MHPC observation area, comprising four target areas (TAs), is larger than the observed section of the MRP, which consists of three TAs. However, the MRP spans 22 kilometers along the riverside with diverse features. This study observed only a portion of that park, selected based on the presence of key components. Therefore, differences in area size may have limited the data.

User profiles included only age group and gender. Due to the observational tool, data collection was limited to remote visual estimation. Only PA type and intensity level were analyzed; external factors were excluded from the discussion. The SOPARC tool employed momentary time sampling, meaning that all findings are based on the specific date and time of observation. This includes the features of the park and the activity type and intensity level of the visitors present at that moment.

5.2. Conclusion and Recommendations

This study aimed to profile the PA observed in two selected UGSs in Marikina City: the Marikina Heights Park Complex (MHPC) and the Marikina River Park (MRP). These parks were designed to promote personal and community development through PA and recreation. A total of 6,948 park visitors were recorded. Of these, 52.55% were male, with the majority belonging to the teenage group (49.83%), while children (13.62%) and the elderly (3.3%) were the least represented.

Approximately 48.34% of visitors engaged in sedentary behaviors, such as socializing, eating, and resting, which still fulfill the park's role in community development. Moderate PA was observed among 47.91% of park visitors, while only 3.74% participated in vigorous PA. Overall, the number of park users engaged in PA exceeded those who remained sedentary. Walking, biking, and dancing emerged as the most common activities.

The findings indicate that both parks have features, amenities, and facilities suitable for individual and group-based PA and recreation. At the same time, these spaces also support sedentary behavior through amenities such as benches and tables. The observed utilization patterns reflect the parks' recreational and developmental purposes.

TAs with features specifically designed for PA, along with those offering organized activities, successfully promoted PA among specific demographic groups. These features included exercise stations, bars, trails, and pathways. In contrast, open multipurpose spaces allowed the implementation of activities even without specialized infrastructure. Organized programs, therefore, have the potential to foster PA across different demographic groups regardless of the physical setup.

Nonetheless, the selected parks lacked improvements that appeal to children and the elderly. The number of visitors from these groups was notably lower. Moreover, few opportunities for vigorous PA were observed. These findings point to opportunities for implementing outdoor PA programs and expanding park features that are inclusive and suitable for a wider range of users. Organized activities can also contribute to increasing PA among older adults (Zhai et al., 2020; Levy-Storms et al., 2017; Cohen et al., 2011). In the case of children, facilities supporting unstructured, spontaneous play are especially relevant (Padial-Ruz et al., 2021). Expanding infrastructure to support vigorous PA, such as sports fields, extended trails, and additional exercise stations, is also recommended.

The findings suggest that UGSs, such as public parks, enhance connectivity within the urban environment. Students, pedestrians, and bikers use these spaces as throughways to schools, commercial areas, and residential zones. Improved infrastructure for active transport within UGS can strengthen urban connectivity while offering safe and healthy environments for the public. This furthers the objective of community and personal development through active transport-based PA.

Marikina City is recognized as a Healthy City due to its numerous initiatives supporting public and environmental health. This study demonstrates that programs focusing on UGS development have effectively encouraged PA in the local community. However, ongoing expansion is needed. Urban planners and local governments in Marikina and other Philippine cities may benefit from implementing similar initiatives to promote PA. As urbanization continues and physical inactivity persists, the presence of accessible UGS becomes increasingly critical—even in densely developed areas.

Finally, this study acknowledges its limitations. Future research may extend the study period and include additional parks in Marikina or other locations. A longitudinal approach could offer more robust insights. Moreover, future studies could expand the demographic profile beyond age and gender and explore the role of socioeconomic and environmental factors. Surveys and interviews may provide a deeper understanding of user motivations and experiences. Advanced statistical analyses can also enrich future studies and strengthen the generalizability of the results. These efforts may further guide UGS development and policy planning to support more active, inclusive, and connected urban communities.

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ASSESSING THE IMPACT OF NIGERIAN SEAPORTS' OPERATIONAL PERFORMANCE ON THE CONSTRUCTION SECTOR'S CONTRIBUTION TO GDP

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ABSTRACT

The construction sector in Nigeria relies heavily on imported materials; however, inefficiencies and frequent delays at the seaports have led to increased costs, significantly affecting the sector's contribution to the nation's Gross Domestic Product (GDP). This study examines the relationship between the operational performance of Nigerian seaports and the GDP contribution of the construction sector. Secondary data on GDP and port performance indicators were obtained from the Central Bank of Nigeria (CBN) and the Nigerian Ports Authority (NPA), covering the period from 2011 to 2023. The analysis employed descriptive and inferential statistics methods, including regression and Stochastic Frontier Analysis (SFA). The findings reveal that the key performance indicators such as Cargo Throughput (LnCTHP), Personnel Efficiency (LnP), and Ship Traffic (LnST) significantly and positively influence GDP, with β-values of 0.462, 0.283, and 0.402, respectively ($p < 0.05$). In contrast, inefficiencies represented by prolonged Turnaround Time (LnTAT) and Waiting Time (LnWT) had negative effects on GDP, with β-values of −0.178 and −0.098, respectively ($p < 0.05$). Additionally, Gross Registered Tonnage (LnGRT) was found to have a positive influence on GDP ($\beta = 0.213$, $p = 0.017$), highlighting the economic benefit of accommodating larger vessels. The regression model demonstrated strong explanatory power, with an R^2 of 0.908 and an adjusted R^2 of 0.882, indicating that the included variables could explain 88.2% of the variance in GDP. These findings are consistent with previous research and highlight the crucial role of port efficiency in driving economic growth. The study recommends focused investments in modern cargo handling technologies, workforce optimization, and infrastructure upgrades to mitigate delays. It also advocates for strategic partnerships with international shipping companies and policy interventions, such as tax incentives for modernization and simplifying customs procedures, to enhance overall efficiency. Future research should further explore the role of port digitalization in facilitating GDP growth. Addressing existing inefficiencies and leveraging operational improvements can support Nigerian seaports in substantially contributing to the construction sector's GDP, thereby supporting broader sustainable economic development.

Keywords: Construction; Impact; Nigerian GDP; Operational performance; Seaports

1. INTRODUCTION

Operational performance at Nigerian seaports significantly influences the country's economic sectors, particularly the construction industry, which remains a key contributor to national GDP. Seaports are critical entry points for essential construction inputs such as cement, steel, and heavy machinery required for infrastructure development. However, inefficiencies in cargo handling, congestion, and

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required for infrastructure development. However, inefficiencies in cargo handling, congestion, and inadequate facilities have led to project delays, increased costs, and a decline in the sector's overall economic output. Previous studies have consistently demonstrated a strong positive link between port efficiency and economic growth, suggesting that improved infrastructure and port operations can meaningfully raise GDP levels. For example, seaport facilities in Apapa and Tin can handle a major share of Nigeria's trade and play a vital role in shaping construction activity and maintaining economic stability economic stability (Nwaogbe et al., 2020). Enhancing operational performance at these ports is thus critical to supporting the construction sector and promoting long-term economic development in Nigeria.

Despite various reform efforts, seaport operations in Nigeria continue to face systemic challenges that adversely affect the construction industry. These challenges include high port charges, delays in cargo clearance, and persistent shortages of imported materials, all of which contribute to project disruptions and cost escalation (Isang & Ebiloma, 2022; Gbolahan et al., 2022). Furthermore, although privatization was introduced to improve port performance, the sector remains hindered by multiple taxation and inefficient intermodal transport systems (Omoke et al., 2017; Ndikom & Obed, 2013). Poor planning and weak stakeholder coordination-often exacerbated by corruption-further impair project delivery, resulting in frequent cost overruns and extended timelines (Unegbu et al., 2023). These persistent challenges highlight the urgent need for stronger regulatory oversight and strategic management to improve port efficiency in ways that directly support the construction industry (Olaogbebikan et al., 2014).

While many studies have examined port operational performance and its general influence on economic output, few have specifically explored the impact on GDP generated by the construction sector. Despite prior research on port efficiency (Omoke et al., 2017; Gbolahan et al., 2021; Gbolahan et al., 2022; Nwaogbe et al., 2020; Isang & Ebiloma, 2022), there remains a gap concerning its direct implications for Nigeria's construction-related GDP. This study addresses that gap by evaluating how the Nigerian seaport's operational performance affects the construction sector's contribution to the country's Gross Domestic Product (GDP).

2. LITERATURE STUDY

2.1. Seaports

A seaport is a designated area along a coastline where ships dock to load or unload passengers and cargo. It is a vital node in the movement of goods across regions and continents, playing a central role in global trade and logistics. Typical seaport infrastructure includes transport links to inland destinations, storage facilities, customs offices, and container terminals (Merk & Notteboom, 2015).

Seaports are essential to international supply chains, functioning as strategic interfaces between maritime routes and inland transportation systems. Their role is particularly significant in supporting industries that rely on timely access to materials, such as construction. The construction sector depends heavily on imported raw materials, including cement, steel, and timber, and on the ability to export finished products. Efficient port operations help minimize delays and reduce vessel turn-around time, which is critical for timely project delivery. Improvements in port infrastructure, including terminals and cargo-handling systems, are necessary to accommodate larger vessels and rising cargo volumes. Such enhancements contribute to improving construction activities' performance (Omoke et al., 2017; Ndikom & Obed, 2013).

2.2. Seaports Operational Performance

The operational performance of seaports plays a pivotal role in enhancing the efficiency and competitiveness of maritime transport, with direct implications for economic development (Omoke

et al., 2017; Gbolahan et al., 2021). Various assessment methodologies have been developed to evaluate port performance, including Data Envelopment Analysis (DEA) and integrated fuzzy approaches. For instance, container vessels at Tanjung Emas Port typically require approximately 23 hours for clearance, while other ports may take over 24 hours, indicating differences in operational efficiency (Simanjuntak et al., 2024).

A model known as ECOGRAISIM has demonstrated significant improvements in service rates and reductions in delays and costs at multimodal terminals. These outcomes affirm the importance of robust operational planning, as discussed by Mouafo Nebot and Wang (2022). In another study, Nguyen et al. (2024) analyzed financial ratios to assess the operational performance of Vietnamese seaport enterprises, offering a comprehensive perspective on their efficiency. While ports in Vietnam, Tanjung, Shangai, Singapore, Rotterdam, and Busan typically operate with clearance times ranging from 12 to 24 hours, Nigerian ports face extended delays, with cargo clearance often taking several weeks (Omoke et al., 2017).

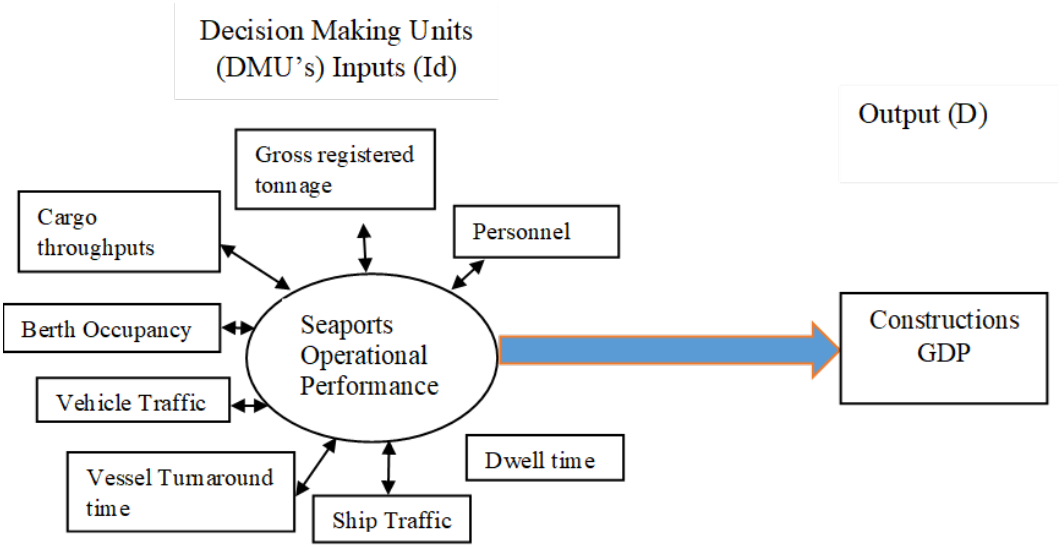

Figure 1 Application of Logistics Performance Theory (Authors design, 2024)

2.2.1. Cargo Throughput

Cargo throughput refers to the total volume of cargo, measured either by weight or unit count, that passes through a seaport within a specific period. It serves as a key indicator of port operational performance, reflecting the capacity and efficiency of cargo handling activities. Standard measurement units include metric tons, TEUs for containerized goods, or other units depending on the cargo type.

2.2.2. Gross Registered Tonnage (GRT)

Gold Registered Tonnage denotes the total internal volume of a ship, measured in register tons, where one register ton equals 100 cubic feet. This metric is widely used to estimate a vessel's size or capacity and forms the basis for calculating port dues and charges under applicable regulations.

2.2.3. Personnel

Human resources in seaports are essential for maintaining efficient operations, regulatory compliance, and logistics coordination. The port workforce encompasses a broad range of specialized roles that contribute to the daily functioning of various port activities.

2.2.4. Dwell Time

Dwell time represents the duration cargo, containers, or vessels remain at a seaport from arrival to departure. This metric is crucial in evaluating port efficiency, as shorter dwell times are associated with faster cargo processing and lower operational costs.

2.2.5. Ship Traffic

Ship traffic indicates the number and movement of vessels entering and exiting a seaport or maritime area. It reflects the level of port activity and is a vital metric for assessing operational capacity. Managing ship traffic effectively helps reduce congestion, ensures safety compliance, and supports optimal resource allocation.

2.2.6. Vehicle Traffic

Vehicle traffic encompasses the movement and volume of vehicles within the port environment, including those involved in cargo transport and logistics operations. Effective vehicle flow management reduces congestion, improves safety, and enhances port performance.

2.2.7. Ship Turnaround Time

Ship turnaround time measures a vessel's total period at the port, from arrival to departure. This metric is a key indicator of operational efficiency, reflecting how promptly berthing, cargo handling, and departure processes are completed.

2.2.8. Berth Occupancy

Berth occupancy refers to the number of hours a berth is in use within a specific timeframe. It is commonly expressed as a percentage of total available time and is an important indicator of berth utilization and port capacity efficiency.

2.2.9. Gross Domestic Product (GDP)

Gross Domestic Product is the aggregate monetary value of all goods and services produced within a country during a period. In this context, the construction sector's contribution to GDP serves as a measure of economic significance. As a critical driver of infrastructure development and employment, construction is central to stimulating economic activity, particularly in developing economies.

2.3. Comparative Study of Ports' Turnaround Time

Comparisons between Nigerian seaports and internationally recognized high-performing ports such as those in Singapore and Rotterdam provide valuable insight into potential areas for improvement. These ports are known for their operational efficiency, advanced digital infrastructure, and well-organized customs procedures. For example, the Port of Singapore achieves vessel turnaround times ranging from 0.5 to 0.7 days, supported by automation and integrated port management systems. Similarly, the Port of Rotterdam maintains average turnaround times of 1.1 to 1.3 days through effective coordination, streamlined customs processes, and robust infrastructure.

In contrast, Nigerian seaports such as the Lagos Port Complex experience much longer turnaround times, averaging between 4.5 and 7 days. Some vessels encounter even greater delays due to congestion, manual processing, and outdated infrastructure. These disparities highlight significant operational inefficiencies in Nigerian port systems (UNCTAD, 2023).

2.4. Construction Sector in Nigeria

The construction industry holds substantial importance in Nigeria's economy but faces numerous challenges. These include bureaucratic delays, corruption, and inadequate infrastructure, all of which hinder project execution and escalate overall costs (Nwaogbe et al., 2020). Additionally, structural

failures in buildings have been attributed to weak regulatory enforcement and the use of substandard materials, raising concerns about safety environmental risks (Ichendu et al., 2024)

Sustainable construction is increasingly recognized as a strategy for improving social and economic conditions, offering benefits such as job creation and increased property value (Unegbu et al., 2024). However, this approach remains underutilized due to limited awareness, weak policy support, and unsustainable practices. Achieving a more resilient construction sector requires comprehensive reforms, active community participation, and technological advancements (Unegbu et al., 2023).

2.5. The Relationship between Seaports and Nigeria's GDP

The connection between seaports and national GDP is complex and has important economic development implications. Although cargo throughput and vessel traffic are generally associated with economic activity, some studies report statistically insignificant direct effects on GDP (Omoke et al., 2017).

Nigeria's maritime sector depends heavily on import and export volumes. However, the country's reliance on imports raises concerns about economic sustainability (Chilaka, 2022). Regional competition and uneven development between the river and deep-sea ports further challenge Nigeria's maritime performance and position within West Africa (Chilaka, 2022). While port activities contribute significantly, especially after port concession, the long-term impact depends on improved infrastructure and export diversification.

2.6. The Effect of Seaports on Constructions in Nigeria

Existing studies suggest that the operational performance of Nigerian seaports significantly influences the construction sector's GDP contribution. Inefficiencies in port operations have been linked to negative impacts on economic performance, including slower growth within the construction industry (Maduechesi et al., 2024).

Fluctuating exchange rates and limited export capacity complicate the relationship between maritime sector output and economic sustainability. Although some research notes short-term gains in revenue from port activities, sustained growth remains elusive (Osadume, 2020). Analysis at the Apapa Port reveals that while cargo throughput and vessel traffic have positive effects, their overall influence on GDP remains limited without corresponding infrastructure upgrades. Omoke et al. (2017) advocate for targeted reforms in port management to strengthen the contribution of maritime operations to the construction sector and the broader economy.

2.7. Theoretical Framework

The theoretical foundation of this study lies in the intersection of logistics performance theory and models of economic growth. Logistics performance theory highlights the importance of efficient transportation systems and supply chain operations in supporting trade and economic activity. In Nigeria, reliable seaport operations are critical for the timely delivery of construction materials and equipment needed for infrastructure development.

Complementing this is endogenous growth theory, which suggests that improvements in infrastructure and productivity can significantly enhance a country's economic output. However, port congestion, long dwell times, and limited handling capacity disrupt supply chains and delay construction projects. These inefficiencies reduce the construction sector's GDP contribution and undermine broader economic growth prospects (Munim & Schramm, 2018).

Empirical research highlights the importance of addressing these issues. For instance, Nwaogbe et al. (2020) emphasize how delays at major seaports, including Apapa and Tin Can, constrain construction activities and trade flows. Improving seaport performance through infrastructure upgrades, efficient

logistics planning, and better resource allocation is essential for enhancing construction's contribution to national GDP and advancing long-term development.

3. RESEARCH METHODOLOGY

This study investigates the relationship between the operational performance of Nigerian seaports and the real Gross Domestic Product (GDP) of the construction sector. It covers a 13-year period from 2011 to 2023, selected based on data availability and the relevance of the post-concession era in port operations.

Secondary data were employed for the analysis. Metrics related to port operational performance including ship traffic, vehicle traffic, berth occupancy, gross registered tonnage, dwell time, ship turnaround time, personnel, and cargo throughput were obtained from the Abstract and Statistics Department of the Nigerian Ports Authority (NPA). The corresponding construction sector GDP figures for each year were sourced from the official website of the Central Bank of Nigeria (CBN).

The analysis utilizes both descriptive and inferential statistical methods. Specifically, a combination of regression analysis and Stochastic Frontier Analysis (SFA 4.1) was applied to examine the relationship between variables and to assess inefficiencies in port operations. Both methods support a comprehensive assessment of how seaport performance metrics influence the construction sector. While regression analysis identifies the direction and strength of these relationships, SFA distinguishes between random errors and operational inefficiencies, offering a more nuanced view of performance outcomes.

Nigeria has six conventional seaports: Apapa Port Complex, TinCan Island Port, Rivers Port, Onne Port, Warri Port and Calabar Port. The four major seaports with the highest cargo throughput and ship traffic were selected as the focus of this study: Apapa Port Complex, Tin Can Island Port, Onne Port, and Warri Port (see Figure 2).

Figure 2 Map of Nigeria showing the six major conventional seaports in Nigeria (ArcGIS desktop 10.8, 2024)

3.1. Descriptive Statistics

Descriptive statistics were used to summarize the dataset and explore the association between seaport operations and the construction sector's contribution to GDP. Construction GDP served as the dependent variable, representing the sector's economic output. The independent variables comprised key operational indicators: cargo throughput, personnel, ship traffic, vehicle traffic, berth occupancy, gross registered tonnage, dwell time, and ship turnaround time. These variables collectively reflect the intensity and effectiveness of port operations.

For each variable, standard descriptive statistics were computed: (i)mean (μ) indicates the central tendency of the dataset; (ii) median, identifies the middle value when data are ordered, offering insight into typical operational levels; (iii) standard Deviation (σ), measures variability from the mean, reflecting the extent of data dispersion; (iv) minimum and maximum, provide the observed range of values.

These statistics help reveal data characteristics and identify potential issues such as outliers or skewed distributions.

3.2. Regression Model Specification

Regression analysis examined the relationship between the construction sector's GDP and the selected operational performance indicators. This method supports identifying patterns, measuring the strength of associations, and making inferences.

The coefficient of determination (R^2) indicates how much of the variation in the dependent variable is explained by the independent variables, with values closer to 1 reflecting a better model fit. T-statistics assess the significance of each predictor, while p-values below 0.05 are considered statistically significant, suggesting a low probability that results occurred by chance. These metrics collectively support the evaluation of the reliability and relevance of the regression model.

3.2.1. Linear Regression Model

The multiple linear regression model is specified as:

$$\text{Construction GDP}_i = \beta_0 + \beta_1 \text{ Cargo Throughput}_i + \beta_2 \text{ Personnel}_i + \beta_3 \text{ Ship Traffic}_i + \beta_4 \text{ Vehicle Traffic}_i + \beta_5 \text{ Berth Occupancy}_i + \beta_6 \text{ Gross Registered Tonnage}_i + \beta_7 \text{ Dwell Time}_i + \beta_8 \text{ Ship Turnaround Time}_i + \varepsilon_i$$

The model investigates the determinants of construction GDP using several port-related indicators. The dependent variable, Construction GDP_i, represents the economic output related to construction for observation i. The independent variables include Cargo $Throughput_i$, which refers to the volume of cargo processed; $Personnel_i$, indicating the number of port workers; Ship $Traffic_i$, capturing the number of ships handled; Vehicle $Traffic_i$, referring to the volume of vehicles involved in logistics; Berth $Occupancy_i$, representing the proportion of berth utilization; Gross Registered $Tonnage_i$, which denotes the total internal volume of vessels; Dwell $Time_i$, measuring the duration cargo remains in port; and Ship Turnaround $Time_i$, which reflects the time from vessel arrival to departure. The model parameters include β_0, the intercept representing the baseline Construction GDP, and β_1 to β_8, which are coefficients reflecting the marginal effects of each independent variable. The error term, ε_i, accounts for unobserved factors or random disturbances affecting the model.

3.3. SFA Model Specification

Stochastic Frontier Analysis (SFA) was applied to estimate the efficiency of seaport operations in contributing to construction GDP. SFA extends traditional production function modeling by incorporating a composite error term, distinguishing inefficiencies from random noise.

The model is expressed as:

$$Constructions\ GDPi = f(Cargo\ Throughput_i, Personnel_i, Ship\ Traffic_i, Vehicle\ Traffic_i, Berth\ Occupancy_i, Gross\ Registered\ Tonnage_i, Dwell\ Time_i, Ship\ Turnaround\ Time_i;\ \beta) + v_i - u_i$$

The production function in this model is specified using the Cobb-Douglas functional form, expressed as $f(x{:}\beta) = \beta_o \prod_{j=1}^{n} x_{ij}^{\beta_j}$, where x_{ij} denotes the jth input for observation i and β_j is the coefficient to be estimated. The inputs, or independent variables, include: x_1 for cargo throughput, x_2 for personnel, x_3 for ship traffic, x_4 for vehicle traffic, x_5 for berth occupancy, x_6 for gross registered tonnage, x_7 for dwell time, and x_8 for ship turnaround time. The model also includes two error components: v_i, which captures random noise due to measurement error or external shocks (assumed to be symmetric), and u_i, a non-negative term that represents inefficiency. After estimating the model using maximum likelihood estimation (MLE), several outputs are generated, including the estimated coefficients β_j, which indicate the influence of each input on output; efficiency scores calculated as $1 - u_i$ for each observation; and model diagnostics such as log-likelihood values, likelihood-ratio (LR) tests, and the distribution of inefficiencies.

All variables were transformed logarithmically to address data skewness, stabilize variance, and linearize multiplicative relationships, thereby improving model robustness and satisfying key assumptions such as homoscedasticity. Figure 3 shows the significance of the clarity purpose of the research guide through the logical steps of the research analysis and enhances the replicability of the research framework.

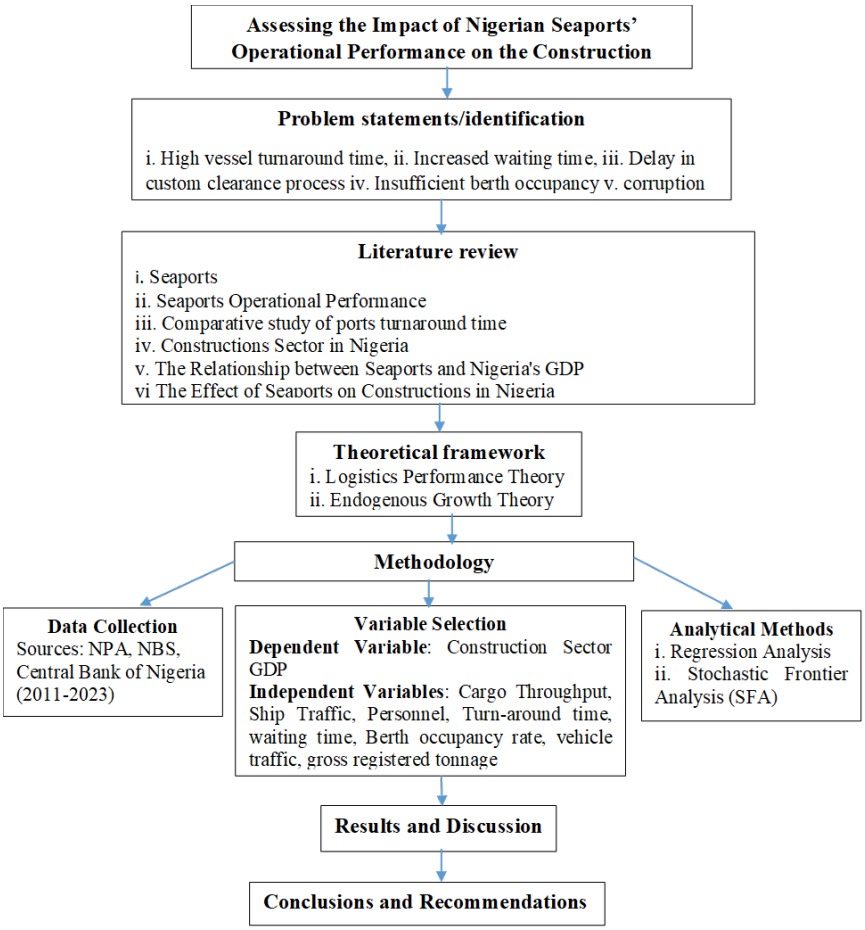

Figure 3 Flow chart for the Impact of Nigerian Seaports' Operational Performance on the Construction (Authors design, 2024)

4. RESULTS AND DISCUSSION

The descriptive statistics in Table 1 summarize the central tendencies and variability of the variables used in the analysis. The natural logarithm of Gross Domestic Product (LnGDP) has a mean of 7.83 with a standard deviation (SD) of 0.13, and values ranging from 7.51 to 7.91. Cargo Throughput (LnCTHP) shows a mean of 18.06 (SD=0.06SD), indicating low variability across the observed period, with values between 17.95 and 18.15.

Table 1 The Descriptive Statistic Summary

Variable	Mean	Standard Deviation	Minimum	Maximum
LnGDP	7.828	0.129	7.505	7.913
LnCTHP	18.058	0.061	17.946	18.15
LnP	5.908	0.108	5.727	6.026
LnTAT	2.922	0.137	2.675	3.162
LnBO	5.07	0.177	4.686	5.281
LnST	8.213	0.129	8.068	8.424
LnVT	12.242	0.305	11.564	12.739
LnGRT	18.508	0.125	18.267	18.682
LnWT	1.385	0.535	0.728	2.715

Personnel (LnP) has a mean of 5.91 and a standard deviation of 0.11, with values ranging from 5.73 to 6.03. The mean value for Turnaround Time (LnTAT) is 2.92 (SD=0.14), with observed values ranging from 2.68 to 3.16. Berth Occupancy (LnBO) records a mean of 5.07 (SD=0.18), with values between 4.69 and 5.28.

Ship Traffic (LnST) exhibits a mean of 8.21 (SD=0.13), ranging from 8.07 to 8.42. Among all variables, Vehicle Traffic (LnVT) displays the highest variability, with a mean of 12.24 and a standard deviation of 0.31, ranging from 11.56 to 12.74. Gross Registered Tonnage (LnGRT) has a mean of 18.51 (SD = 0.13), with values spanning from 18.27 to 18.68. Waiting Time (LnWT) presents the highest standard deviation among all variables (SD = 0.54), with a mean of 1.39 and values ranging from 0.73 to 2.72.

These descriptive statistics provide insight into the extent of variation in operational characteristics across Nigerian seaports. The observed differences in magnitude and dispersion suggest varying levels of performance, which may influence the construction sector's contribution to GDP.

The regression results presented in Table 2 demonstrate the significant influence of Nigerian seaport operational performance on the construction sector's Gross Domestic Product (GDP). The natural logarithm of Cargo Throughput (LnCTHP) exhibits a strong positive association with construction GDP (β=0.462, $p < 0.001$ suggesting that higher cargo handling volumes contribute meaningfully to economic output. Similarly, Personnel (LnP) shows a statistically significant positive relationship (β=0.283, $p = 0.023$), highlighting the importance of labor efficiency in supporting sectoral growth. Ship Traffic (LnST) also emerges as a key determinant (β=0.402, $p < 0.001$), reflecting the role of vessel movement in sustaining economic activity.

Table 2 Regression Analysis

Variable	Coefficient (β)	Standard Error	t-Statistic	p-Value
Intercept	1.872	0.785	2.385	0.028
LnCTHP	0.462	0.089	5.191	<0.001
LnP	0.283	0.114	2.482	0.023
LnTAT	-0.178	0.072	-2.472	0.024
LnBO	0.091	0.065	1.4	0.179
LnST	0.402	0.078	5.154	<0.001
LnVT	-0.062	0.038	-1.632	0.131
LnGRT	0.213	0.081	2.63	0.017
LnWT	-0.098	0.043	-2.279	0.037
Model Statistics				
R-squared: 0,908				
Adjusted R-squared: 0.882				
F-statistic: 51.784				
Prob (F-statistic): <0.001				

In contrast, Turnaround Time (LnTAT) has a negative effect on GDP ($\beta=-0.178$, $p = 0.024$), indicating that operational delays at ports can hinder construction output. Gross Registered Tonnage (LnGRT) shows a positive effect ($\beta=0.213$, $p = 0.017$), emphasizing the economic value of accommodating larger ships. Waiting Time (LnWT) is negatively associated with GDP ($\beta=-0.098$, $p = 0.037$), further reinforcing the adverse impact of inefficiencies in port processing.

The regression model exhibits strong explanatory power, with an R^2 value of 0.908 and an adjusted R^2 of 0.882. This indicates that the included independent variables can account for approximately 88.2% of the variation in construction GDP. These findings align with earlier studies, including those by Yuen et al. (2012) and Rodrigue and Notteboom (2011), which recognize port performance as a critical driver of economic development.

Improving port operational efficiency particularly by minimizing turnaround and waiting times holds considerable potential to enhance the construction sector's contribution to Nigeria's GDP. These results suggest that targeted port management and infrastructure reforms could yield measurable economic benefits.

The Stochastic Frontier Analysis

The Stochastic Frontier Analysis (SFA) results for Nigerian seaports, presented in Table 3, offer insights into the key operational factors influencing port efficiency concerning the construction sector's Gross Domestic Product (GDP). The constant term ($\beta_0=0.9427$, SE=0.9991, t=0.9436) suggests a baseline efficiency level in port operations. However, its lack of statistical significance indicates that factors not included in the model may also affect performance outcomes.

Cargo Throughput ($\beta_1=1.1208$, SE=0.6799, t=1.7760) has the highest positive coefficient among all variables. Although only marginally significant, this result emphasizes its importance in improving operational efficiency, consistent with prior studies that identify throughput as a central determinant of port productivity (Wang et al., 2021). In contrast, variables such as Personnel ($\beta_2=-0.4704$, SE=0.8805, t=−0.5342), Turnaround Time ($\beta_3=-0.7472$, SE=0.8431, t=−0.8863), and Berth Occupancy ($\beta_4=-0.4664$, SE=0.6757, t=−0.6903) show negative coefficients. These findings point to operational inefficiencies that may arise from suboptimal workforce allocation, scheduling conflicts, or congestion-related challenges.

Ship Traffic (β_5=0.4037, SE=0.8468, t=0.4767) and Vehicle Traffic (β_6=0.0590, SE=0.2033, t=0.2904) have positive but statistically insignificant coefficients, suggesting limited immediate effects or the presence of latent variables that warrant further investigation. Gross Registered Tonnage (β_7=−0.6258, SE=0.5806, t=−1.0779) and Waiting Time (β_8=−0.0753, SE=0.0886, t=−0.8494) negative associations with efficiency, potentially due to physical infrastructure constraints or operational delays.

Table 3 Maximum Likelihood Estimates of the Stochastic Frontier Analysis of the Seaports

Variable	ML Estimates		
	Coefficient	Standard Error	t-ratio
Constant	0.9427	0.9991	0.9436
Cargo throughputs	1.1208	0.6799	1.7760
Personnel	-0.4704	0.8805	-0.5342
Turnaround time	-0.7472	0.8431	-0.8863
Berth Occupancy	-0.4664	0.6757	-0.6903
Ship Traffic	0.4037	0.8468	0.4767
Vehicle Traffic	0.0590	0.2033	0.2904
Gross Registered Tonnage	-0.6258	0.5806	-1.0779
Waiting Time	-0.0753	0.0886	-0.8494
Sigma squared	0.0059	0.0027	2.1821
Gamma	1.0000	0.0038	26.3945
LR test	4.5439		
Log likelihood function	33.0312		

The error component of the model, represented by sigma-squared ($\sigma 2$=0.0059, SE=0.0027, t=2.1821), is statistically significant, justifying the inclusion of inefficiency effects in the model specification. The gamma value (γ=1.000, SE=0.0038, t=26.3945) suggests that deviations from the efficiency frontier are almost entirely due to inefficiencies rather than random noise.

The Likelihood Ratio (LR) test statistic of 4.5439, along with the log-likelihood value of 33.0312, reinforces the robustness of the model. The LR test rejects the null hypothesis (H_0: γ=0), which assumes that all deviations from the frontier are attributable to random error, thereby confirming the presence of significant inefficiencies affecting seaport performance.

The log-likelihood value indicates a well-fitting model capable of capturing the relationship between operational variables and port efficiency. Together with the significant inefficiency components, the results validate the use of SFA in this context. These findings offer practical insights for policymakers and industry stakeholders aiming to improve port operations. Addressing inefficiencies particularly those related to turnaround time, berth utilization, and workforce management can support efforts to enhance operational performance and, in turn, strengthen the construction sector's contribution to Nigeria's GDP.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

This study demonstrates a strong relationship between the operational efficiency of Nigerian seaports and the construction sector's contribution to the Gross Domestic Product (GDP), based on evidence from regression and Stochastic Frontier Analysis (SFA). Key performance indicators including ship traffic, personnel efficiency, and cargo throughput contribute significantly to economic output. These results highlight the importance of efficient labor management, active vessel operations, and streamlined cargo handling. The findings align with previous studies by Gbolahan et al. (2021) and

Omoke et al. (2017), which identified similar factors as influential in determining port-related economic performance. On the other hand, operational inefficiencies particularly extended turnaround times and prolonged vessel waiting periods negatively affect GDP. These delays reduce construction sector productivity, thereby constraining economic growth. Gross Registered Tonnage also positively correlates with GDP, suggesting the economic value of accommodating larger vessels and improving port handling capacity.

The significance and reliability of the analytical models are further supported by the work of Yuen et al. (2012) and Rodrigue and Notteboom (2011), who emphasized the critical role of port performance in shaping economic outcomes. Based on the findings, there is a clear need for regulatory interventions aimed at minimizing operational bottlenecks, such as turnaround delays and waiting times, to enhance port productivity and strengthen the construction sector's economic impact.

Future research is encouraged to explore the role of digitalization in port operations and its potential contribution to economic performance. A deeper understanding of digital infrastructure and smart port systems could provide valuable insights into strategies for achieving more efficient and sustainable economic growth.

5.2. Recommendations

To improve the operational performance of Nigerian seaports and strengthen their impact on the construction sector's contribution to GDP, several strategic actions are proposed. First, investment in modern cargo handling systems is critical. Government agencies and private port operators should focus on upgrading infrastructure through automated systems, advanced logistics technologies, and staff development initiatives. These measures can increase cargo throughput and enhance operational effectiveness, which supports broader economic growth. Additionally, increasing capacity for larger vessels offers further potential benefits. The observed link between gross registered tonnage and GDP suggests that expanding draft depth through dredging and constructing berths for high-capacity ships may help improve port efficiency and attract more maritime traffic.

Workforce optimization is also an important area of focus. The demonstrated influence of personnel efficiency on GDP highlights the value of improving human resource performance. Port authorities are encouraged to provide ongoing professional development opportunities, apply performance-based reward systems, and adopt digital platforms for workforce deployment and scheduling. These steps can help maintain high levels of efficiency and responsiveness in port operations, contributing positively to economic outcomes.

Finally, reducing turnaround and waiting times remains vital. To address this challenge, port management should focus on simplifying customs clearance processes, improving vessel scheduling systems, and upgrading essential infrastructure to accommodate simultaneous ship traffic. Alongside these efforts, systematic performance monitoring is necessary. A strong framework for regular performance assessment using Key Performance Indicators (KPIs) can help identify inefficiencies and guide improvements. Data-driven evaluations should inform operational decisions and support consistent progress across seaport activities.

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THE CITY AS THE CLASSROOM: THE CASE OF "START 'EM YOUNG ADVOCACY" AT SILLIMAN UNIVERSITY, PHILIPPINES

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ABSTRACT

This case study highlights the value of engaging with communities as real-world environments for practical and reflective learning. It suggests that students can develop insights and acquire knowledge through interactions with diverse groups and locations, even within urban settings. The paper presents the experience of implementing the "Start 'em Young Advocacy," a student-led, environment-focused, and project-based initiative within the Civic Welfare Training Service (CWTS) under the National Service Training Program (NSTP) at Silliman University, Philippines. In collaboration with the City Social Welfare and Development Office (CSWDO), CWTS students worked with thirty daycare centers. Using Kolb's Experiential Learning Theory as a framework, this study explores student learning outcomes based on their written reflections, applying the "Head, Heart, and Feet" model. The results suggest that involvement in this program contributes to developing knowledge and skills, shifts in attitude and emotion, and forming future plans or initiatives. Overall, this paper presents urban environments as active learning spaces that support student development and provide opportunities to contribute to the United Nations Sustainable Development Goals (UN SDGs).

Keywords: Experiential learning; Learning environmental

1. INTRODUCTION

Experience and engagement are powerful drivers of student learning, particularly within the Civic Welfare Training Service (CWTS) component of the National Service Training Program (NSTP) at Silliman University in Dumaguete City, Philippines. CWTS is a government-mandated training program under the Republic Act (RA) 9163. This law emphasizes the Filipino youth's vital role in nation-building and promotes civic consciousness while supporting their physical, moral, spiritual, intellectual, and social development. It aims to cultivate patriotism, nationalism, and active public and civic engagement (Section 2, NSTP Act, Dew). Moreover, CWTS, as defined in the NSTP Act, involves "programs or activities contributory to the general welfare and the betterment of life for the members of the community or the enhancement of its facilities, especially those developed to improving health, education, environment, entrepreneurship, safety, recreation and morals of the citizenry" (Section 4, NSTP Act, 2001). Higher education institutions (HEIs) in the Philippines are directed to motivate, train, organize, and mobilize students in military training, literacy, civic welfare, and similar endeavors in service to the nation.

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CWTS and the other NSTP components, Reserve Officer Training Corps (ROTC) and Literacy Training Service (LTS), integrate experiential learning as a central pedagogical strategy, supported by conventional methods such as lectures and workshops. Each component offers a combination of theoretical instruction and hands-on experiences that prepare students with the competencies required for meaningful community engagement.

Student involvement and direct experience are integral to learning. Students are encouraged to apply theoretical concepts in real-life situations, addressing problems within relevant and immediate contexts (Cashman et al., 2008). These engagements generate meaningful experiences that support the achievement of learning goals (Chan, 2012).

This case study examines the experiences and insights gained from the "Start 'em Young Advocacy" program, a CWTS initiative under NSTP at Silliman University. "Start 'em Young Advocacy" is a student-led, project-based initiative focused on environmental themes and guided by a self-directed, experiential learning approach. CWTS cadets participated by working with thirty (30) daycare centers under the City Social Welfare and Development Office (CSWDO).

Ultimately, this case study highlights how urban spaces serve as valuable environments for student learning. These spaces provide transformative experiences and create opportunities for contributing to the United Nations Sustainable Development Goals (UN SDGs).

2. LITERATURE REVIEW

2.1. Experiential Learning

Experiential Learning (EL) is a widely used approach to teaching and learning. It has been applied across context- and discipline-specific learning activities in various fields, including Agricultural Education (Jurlano & Ablan, 2024), Global Public Health (Ezezika & Gong, 2020), Health Science (Almanag et al., 2022), General Education (Chiu, 2019), and Civic Education (Oliver, 2021). It has remained a relevant educational trend in recent years despite changes in learning contexts (Katula & Threnhauser, 1999).

Experiential Learning Theory traces its origins to Dewey's philosophy of education, initially referred to as a "theory of learning" (Kolb & Kolb, 2005). Dewey argued, as cited by Kolb et al. (2005), that traditional education relies heavily on convention and thus requires no theoretical basis. In contrast, experiential learning requires a dependable theoretical framework to support its application. Dewey (1944), as cited in Austin et al. (2015), stated that learning does not emerge from experience alone but arises from the "reconstruction or reorganization of experience that adds to the meaning of that experience and which increases the ability to direct the course of subsequent experience." This highlights the importance of reflection in experiential learning as a key element in generating knowledge.

Kolb (1984) initially defined experiential learning as "the process whereby knowledge is created through the transformation of experience." He later refined this definition to describe it as a learning cycle or spiral in which the learner engages in a continuous sequence of experiencing, reflecting, thinking, and acting, where immediate or concrete experiences form the foundation for observations and reflections (Kolb & Kolb, 2005). Building on this foundation, Kolb and Kolb (2005), as cited in Austin et al. (2015), proposed six key assumptions underlying Experiential Learning Theory (ELT): (i) learning is best understood as a process rather than as an outcome; (ii) all learning involves relearning; (iii) learning involves resolving conflicts between opposing ways of adapting to the world; (iv) learning is a comprehensive process of adapting to the world; (v) learning emerges from interactions between the individual and the environment; and (vi) learning is the process of constructing knowledge.

Kolb (1984) developed a framework that identifies four interrelated aspects of experiential learning: concrete experience, reflective observation, abstract conceptualization, and active experimentation. This process is illustrated in Figure 1.

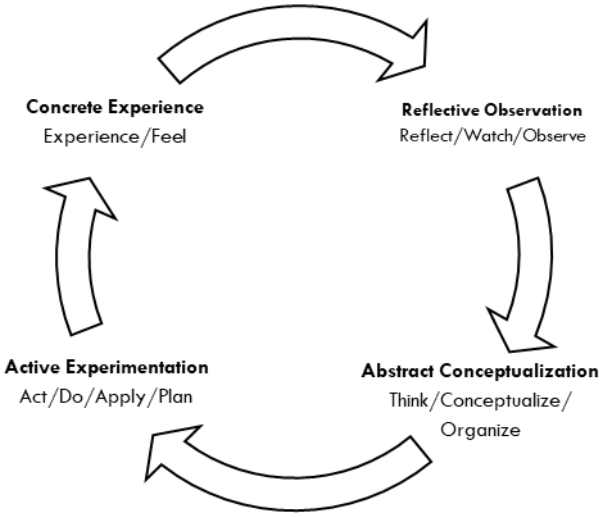

Figure 1 Theory Model of Kolb's Experiential Learning

In Kolb's model, as Ezezika et al. (2020) discussed, concrete experience refers to students' direct involvement in learning activities, including fieldwork, games, or classroom simulations. Reflective observation involves students thinking about what they have learned and relating it to prior experiences. Abstract conceptualization asks students to integrate previous knowledge, theories, and concepts into their understanding. In active experimentation, students apply what they have learned by engaging in new situations.

According to Kolb & Kolb (2005), cited in Ezezika et al. (2020), the model is not a linear process but a cyclical one. Students can begin at any stage and flexibly move through the cycle. They are encouraged to participate in all cycle stages, regardless of their entry point.

A key element of EL is recognizing how the learning environment shapes the process. Kolb et al. (2005) emphasize that learning results from dynamic exchanges between individuals and their surroundings. This perspective is supported by Beard et al. (2006), who describe experiential learning as a "sense-making process of active engagement between the inner world of the person and the outer world of the environment." Students may enter any stage of Kolb's model through experiences in different settings. Learning is not confined to the classroom, and the spaces where students engage directly influence the learning process. Kolb et al. (2005) further built on Lewin's "life space" concept, highlighting the interaction between an individual's learning style and educational environment.

2.2. City as a Learning Environment

This study considers the city as a learning environment, drawing from the works of Kolb et al. (2005), Beard et al. (2006), and Hassink et al. (2012). Learning can occur beyond traditional classrooms' confines and may appear in various settings, including urban spaces. Hassink et al. (2012) noted that "people can receive and understand information during their lives in cities and urban environments." In line with this, multiple studies have identified cities as important environments for learning, where students encounter experiences that shape their knowledge, perspectives, and values.

Cities have historically served as powerful sites for education. Bailey (1971) asserted that cities have functioned as classrooms long before the formalization of schools, playing a critical role in the educational development of individuals. He described the city as:

> "… the focal point for the creation and reproduction and display of almost everything beautiful and ennobling and memorable in our civilization…in and around cities are the centers of vast enterprises of commerce and industry, of medicine and social services, of transportation and communications…cities are foci of modern guilds, labor unions…[are] important part of our total educative system…cities are ecological laboratories…where sheer numbers of interacting people provide marvelous observation for human behavior and behavioral consequences."

Neta (2015) reflected on how cities shape the learning of students and citizens through various mechanisms. Cities provide a framework for diverse educational encounters, including formal and informal learning experiences. Trilla (1999) described cities as maintaining a constant structure of teaching and learning, which educational institutions actively adopt. Furthermore, cities serve as platforms where people, ideas, objects, and techniques intersect, contributing to knowledge development. According to Rama (1985) and Sennett (2003), as cited in Neta (2015), everyday aspects of city life, such as social customs, interactions, and shared spaces—contribute to this dynamic exchange, giving rise to new meanings and transformative experiences.

The value of cities in education lies in their capacity to broaden the scope of learning, strengthen democratic participation, redefine concepts of citizenship, and expand educational and cultural networks (Brarda et al., 2004). Rajabi et al. (2021) propose that learning is most effective not merely because of the environment but due to the actions and meanings that emerge from within it. This view supports the idea that students actively direct their learning by engaging with their surroundings and the experiences they offer. Such a perspective shifts away from traditional teacher-centered instruction. Learning in urban spaces supports social and participatory learning principles while promoting opportunities for self-reflection and personal growth (Kolb, 2000).

3. METHODS

This qualitative study adopts a case study design and applies thematic analysis to generate and interpret data. A case study is appropriate for examining in-depth "programs, events, activities, processes, or one or more individuals…bound by time and activity" (Cresswell, 2014). The present case centers on the "Start 'em Young Advocacy" of the CWTS.

Data were drawn from individually written reflection papers submitted by CWTS cadets and group reflection presentations completed during the 2023–2024 academic year. Additional sources include internal documents, reports, and published materials about CWTS and student involvement in communities at Silliman University.

The case study design is suitable for examining a "phenomenon in a real-life context" (Yin, 2009), focusing on the experiences of CWTS cadets who participated in the program. Students submitted written reflections after completing five sessions held on Saturdays in their assigned daycare centers.

Thematic analysis was conducted using Braun and Clarke's reflexive thematic analysis method (Braun & Clarke, 2006, 2013, 2019a), which provides a flexible framework for identifying and interpreting patterns. A deductive or "theory-driven" analytic approach was adopted, guided by Kolb's Experiential Learning Framework (1984). Codes were organized according to the four components of Kolb's model: concrete experience, reflective observation, abstract conceptualization, and active experimentation, accompanied by selected quotations.

The case study design and theory-informed approach were selected to analyze students' complex and meaningful reflections about their experiences in the "Start 'em Young Advocacy" within the lens of Kolb's Experiential Learning Framework.

4. THE CASE

4.1. CWTS and NSTP at Siliman University

At Siliman University, the learning activities in CWTS are closely aligned with the Whole Person Education (WPE) philosophy, which serves both as an approach and a goal of teaching and learning. The integration of Republic Act No. 9163 with Silliman University's WPE is reflected in the "5 Cs": classroom, court, cultural center, church, and community as key learning venues. Among these, the community is central in cultivating social responsibility and encouraging a people-oriented perspective (Maestrecampo, 2022).

As Maestrecampo (2022) emphasized regarding the role of community within the 5 Cs at Silliman University:

> "The community is a significant contributor to students' learning. It offers opportunities and experiences for students to apply their knowledge and skills in real-world situations. Student experiences in communities contribute to understanding the three interconnected facets of student life: personal connection (how students have been affected by the experience), academic connection (the relationship of these experiences with theories learned in various subjects), and social connection (a heightened awareness and understanding of community issues and problems and identifying actions students can take to help improve the situation)."

This integration is further supported by Silliman University's vision of being "a leading Christian institution committed to total human development for the well-being of society and the environment." The university upholds its statutory mandate by promoting civic consciousness among the youth, nurturing their physical, moral, spiritual, intellectual, and social well-being, and instilling values of patriotism and nationalism through active participation in public and civic affairs.

The CWTS program includes 25 hours of learning activities focusing on common NSTP topics such as NSTP Orientation, Citizenship Training, Drug Education, Disaster Awareness, Preparedness and Management, Environmental Protection, and other national concerns. In addition, students complete 83 hours of CWTS-specific learning activities, which cover self-assessment and values development, leadership training, dimensions of development, community exposure, agency visits, community needs assessment, community services, and program evaluation. These activities are conducted within one academic year. A distinguishing feature of the program at Silliman University is its strong emphasis on environmental stewardship and alignment with the United Nations' Sustainable Development Goals (UN SDGs) as its guiding focus.

CWTS applies a student-centered approach to learning. Students actively design specific activities that align with the course's learning goals and intended outcomes. This approach allows learners to direct their educational experience, challenging cadets to become independent thinkers. They are encouraged to develop strategies and build confidence through exploration, analysis, and direct involvement rather than relying only on conventional listening, observing, and memorizing content.

4.2. The "Start 'em Young Advocacy" of Siliman University CWTS

The "Start 'em Young Advocacy" functioned as the community engagement component of the CWTS from school year (SY) 2018 to 2022. It was designed as the culminating community engagement and experiential learning activity of the CWTS, implemented after a series of preparatory lectures and workshops. These sessions covered key topics including: (i) the role of the youth in environmental protection and stewardship; (ii) the status of the Philippine environment; (iii) the status of the Philippine marine environment; (iv) solid waste management; (v) fundamentals of disaster risk reduction and management; (vi) citizenship training, volunteerism, and community engagement, with emphasis on self-awareness and values formation aimed at becoming environmental stewards; (vii)

group facilitation and working with children; (viii) project development and management for community development; and (ix) concepts and protocols of community engagement.

Table 1 Project Plan for "Start 'em Young Advocacy"

Session	Learning Objectives	Activities	Budget	Expected Outcome
Earth's Echo	To learn about environmental issues and the human activities that contribute to them. Increase environmental awareness.	Needs assessment and a puppet show.	P300.00 for art materials and snacks	Understanding of environmental issues.
Trash Target	Teach daycare children about the importance of proper waste disposal and recycling in a fun and engaging way.	Recycled art. Relay race.	P300.00 for art materials and snacks	Understanding and development of skills in proper waste disposal.
Hygiene Heroes	To educate young kids on proper hygiene practices, including hand washing and proper brushing teeth. Inform daycare children about the presence of germs.	Healthy or not, game to identify healthy foods. Lecture on good nutrition, balanced diet, food pyramid, and go, grow, and glow foods. Sandwich making	P300.00 for art materials and snacks	Practicing good hygiene and healthy eating habits.
Art Day	Develop creative expression among daycare children by applying what they have learned. Instil values by letting daycare children imagine an ideal future environment.	Movie/video watching about the environment. Hand painting and coloring activities.	P300.00 for art materials and snacks	Application of environmental knowledge through art.
Culmination	Celebrate the new knowledge acquired by daycare children and the implemented impact project.	Talent shows by daycare children and CWTS cadets. Games.	P700.00 for prize and snacks	Celebrating new knowledge and bonding formed with daycare children, daycare teachers, and parents.

These topics were designed to reflect Silliman University's commitment to preventing environmental pollution, conserving and enhancing natural resources, and supporting environmental sustainability, as stated in its Environmental Principles, Policies, and Guidelines 2018 (Board of Trustees Action, Silliman University, November 17, 2018). These subjects were delivered through lectures and workshops facilitated by professors and external resource persons, aiming to deepen CWTS cadets' understanding of each theme's core concepts and theoretical foundations.

After completing these sessions, CWTS cadets convene in groups to design and plan their activities under the "Start 'em Young Advocacy." Their work centers around two goals: first, to translate their acquired knowledge into creative learning activities for daycare children, and second, to implement impact projects addressing the identified needs of daycare centers.

At the same time, CWTS collaborates with the Office of Community Engagement and Service-Learning (OCESL) at Silliman University to coordinate preparations and partnerships with the City Social Welfare and Development Office (CSWDO) in Dumaguete City. OCESL provides logistical and administrative support and offers guidance on the basic procedures for conducting community engagement. The CSWDO helps identify daycare centers that will serve as partner communities for implementing the "Start 'em Young Advocacy".

Tabel 1 presents the structured weekly implementation plan designed for the "Start 'em Young Advocacy," detailing the sequence and focus of activities across five consecutive Saturdays. CWTS cadets are given five (5) Saturdays to carry out the "Start 'em Young Advocacy," each session lasting 3 to 4 hours with daycare children. The implementation starts with a preliminary site visit and courtesy call with barangay officials, during which cadets introduce themselves and explain the program's objectives. During the sessions, cadets work directly with the children by converting lessons on environmental stewardship, solid waste management, and disaster risk reduction and management into interactive and creative learning activities. The goal is for daycare children, starting as early as ages 3 to 4, to begin developing an awareness of caring for the environment, understanding proper waste segregation, and acquiring basic knowledge about appropriate responses to natural calamities and disasters.

4.3. The City and Learning Environment Dumaguete City, Negros Oriental, Philippines

"Start 'em Young Advocacy" was implemented in Dumaguete City, Negros Oriental, Philippines, a second-class component city and the capital of the province. Dumaguete is known as the "City of Gentle People." It serves as a commercial and trading center and an intermediate port of call for inter-island vessels on routes to Manila and the western provinces of Mindanao (International Labor Organization, 2009). Furthermore, Dumaguete is a key transit point for moving people, goods, and services between neighboring regions and islands.

The city is also recognized as an academic hub, home to several higher education institutions (HEIs), including four major universities: Silliman University, Negros Oriental State University, St. Paul University Dumaguete, and Foundation University, along with several colleges. These institutions attract students from surrounding areas and have long been considered the city's lifeblood, contributing to its economic development by creating demand for a wide range of products and services serving local and non-local residents, Filipino and foreign (International Labor Organization, 2009).

Dumaguete has a total land area of 3,425.51 hectares or 55.8 square kilometers and is divided into thirty barangays. These are: Bagacay, Bajumpandan, Balugo, Banilad, Bantayan, Batinguel, Bunao, Cadawinonan, Calindagan, Camanjac, Candau-ay, Cantil-e, Daro, Junob, Looc, Mangnao-Canal, Motong, Piapi, Barangay 1 to Barangay 8, Pulantubig, Tabuctubig, Taclobo, and Talay. Based on the 2020 census, the city has a population of 134,103 people (Philippine Statistics Authority, 2021), making it the most populous and economically productive city in Negros Oriental, despite being the smallest in terms of land area.

The "Start 'em Young Advocacy" was conducted in collaboration with the City Social Welfare and Development Office (CSWDO), targeting the barangays of Tinago, Calindagan, Tabuctubig, Barangay 8, Piapi, Bantayan, Balugo, Taclobo, Bagacay, and Daro.

5. RESULTS

The data in this study were derived from written reflection papers submitted by CWTS cadets who participated in the "Start 'em Young Advocacy." These data are presented and discussed using Kolb's Experiential Learning (EL) Framework (1984), which includes four stages: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. According to Kolb, learning arises from the learner's experience in an activity, followed by a reflective process. However, learning may begin at any point within the cycle and proceed continuously.

5.2. Concrete Experience

The experiential learning process begins with concrete experience, which refers to new or reimagined encounters that engage students through participation. At this stage, learners are involved in a specific activity. Kolb emphasized that involvement is essential for learning, and active engagement plays a key role in acquiring knowledge.

In "Start 'em Young Advocacy," CWTS cadets initially participated in conventional classroom activities, such as lectures, workshops, and demonstrations. These activities were incorporated into their planning process for the advocacy program, which was implemented over four Saturdays. Cadets also considered budget, transportation, and logistical needs when preparing their activities. All plans aligned with the program's key themes, including environmental stewardship, solid waste management, and disaster risk reduction and management. Thematic analysis identified that the cadets' concrete experiences were directly tied to the program's implementation.

Cadets assumed various roles and tasks as agreed upon within their groups and worked collaboratively. This highlighted the importance of teamwork, as one cadet noted:

> "One of the most significant lessons I gained from my participation is the importance of teamwork. Engaging in group activities and fieldwork highlighted the essential role that teamwork plays in achieving common goals and objectives. Working collaboratively with my groupmates made tasks more manageable, efficient, and enjoyable. It taught me the value of cooperation, communication, and mutual support in accomplishing shared tasks effectively."

Cadets also develop personal skills, especially patience, when interacting with young children. One cadet wrote:

> "I realized that my patience had been tested as I interacted with the different personalities and characteristics of the children."

Another cadet commented on discovering patience:

> "I have realized that I am capable of doing things I once thought were beyond my abilities. Through this experience, I discovered a newfound patience within myself, especially when dealing with children. I learned to listen more attentively, respond with kindness, and adapt my teaching methods to meet the needs of each child."

In addition, cadets learned to communicate more effectively by simplifying concepts and delivering them in a way that young children could understand. Leadership also emerged as a developed skill, with cadets contributing ideas, guiding groupmates, and engaging with daycare teachers and children. One cadet noted:

> "I can also say that it developed my leadership qualities such as decision-making, communication, and problem-solving skills."

Another shared:

> "I discovered that I am capable of pushing myself beyond my comfort zone, particularly in improving my communication and leadership skills."

Another shared:

> "This activity not only cleaned the environment but also fostered leadership skills within me, allowing me to motivate and guide others towards a shared goal."

Across multiple reflections, the recurring themes of patience, communication, and leadership highlight these as prominent learning outcomes from cadets' concrete experiences.

5.2. Reflective Observation

After After completing the concrete experience phase, CWTS cadets entered the reflective observation stage. In this phase, learners considered their strengths and limitations while reviewing their roles and tasks during the program. They also evaluated their actions' impacts and their adjustments to meet unforeseen challenges (Ezezika et al., 2020).

Thematic analysis revealed that cadets reflected on self-discovery and personal growth. Many discovered interests in teaching or mentoring children and recognizing growth in interpersonal skills. One cadet shared:

> "I realized that I possess a strong inclination towards nurturing and educating younger generations. I discovered a passion for mentoring and guiding children."

Another reflected:

> "Involvement in CWTS' Start 'em Young advocacy has provided me with valuable insights about myself, such as my passion for teaching and my ability to connect with children."

Cadets also reflected on a deeper understanding of the community and their role within it. One cadet wrote:

> "My understanding of the community shifted from a charity-based approach to one rooted in collaboration and empowerment. I learned to listen actively, respect diverse perspectives, and co-create solutions alongside community members."

Another noted:

> "Initially, I viewed community service as a one-sided act of giving. However, I learned that it's a reciprocal relationship where the giver also receives. The smiles and gratitude from the children and their families taught me about the community's warmth, strength, and solidarity. I now appreciate their diverse challenges and the collective spirit that helps them overcome these hurdles."

Another emphasized collective responsibility:

> "I now see the community as a collective effort where everyone has a role to play. It's not just about individual contributions but how we can work together to uplift each other. The sense of unity and shared responsibility has become more apparent to me, highlighting the importance of collaboration in driving meaningful change."

Adaptability and resilience were also frequent points of reflection. Many cadets faced unfamiliar situations, especially when working with young children. Two cadets wrote:

> "I discovered I could improve my adaptability and resilience when forced outside my comfort zone. I generally struggle to socialize with others and prefer to talk with people I am comfortable with or not talk at all."

> "One of the greatest lessons I gained from my…was the importance of patience and adaptability. Spending four weeks visiting daycares exposed me to the unpredictable nature of working with children. I learned that no matter how meticulously I planned activities, things could steer off course in delightful or challenging ways. This experience taught me to be patient, to embrace

> spontaneity, and to think fast on my feet. It was a crash course in flexibility and resilience, invaluable skills in both personal and professional settings."

These reflections demonstrate cadets developed a more nuanced understanding of community while gaining personal resilience and insight.

5.3. Abstract Conceptualization

In the abstract conceptualization stage, CWTS cadets begin to make sense of their experiences. They synthesize and integrate previous knowledge, concepts, and theories with new learning experiences, creating new theories that explain observations (Ezezika et al., 2020). The reflections of CWTS cadets, as revealed through the thematic analysis, resulted in a more critical and newer concept of the community, encompassing social and economic complexities.

Cadets reported increased awareness of socioeconomic challenges, especially regarding how these issues affect early childhood education. One cadet observed:

> "My understanding of the community evolved significantly. I saw the various socio-economic challenges affecting children's education and development. This deeper awareness of community issues has made me more empathetic and motivated to contribute to positive change."

Another wrote:

> "I realized the differences in the learning requirements and the socioeconomic disparities of the community. This experience thus revealed the immense value of proper education, from an early age, and its part in determining the prospects of children in the future."

The importance of education as a tool for empowerment was emphasized in several reflections. Cadets wrote:

> "This experience highlighted the importance of early education and the need for continuous support to foster their development."

> "I've discovered the profound impact that education and empowerment can have on individuals and communities, as well as the importance of taking proactive steps to address pressing social and environmental issues."

Others emphasized the role of community engagement as a collective effort. They stated:

> "My understanding has profoundly changed through our fieldwork. I now see the community as vibrant and resilient, filled with curious and enthusiastic children who crave learning and social interaction. This experience revealed the underlying strengths and potential within the community, highlighting the critical role of educational and recreational activities in fostering a supportive and nurturing environment for its younger members."

> "I became more aware of children's challenges in underprivileged areas, including limited access to quality education and recreational activities. This experience opened my eyes to the broader societal issues and the importance of community support and development programs. For example, seeing children eager to learn despite lacking resources highlighted the critical need for educational support and inspired me to advocate for better educational opportunities."

> "The Eco-Warrior Project reinforced the idea that small, community-based actions can lead to significant environmental changes…this project reinforced a critical realization: effective community engagement is fundamentally a collective effort."

> "The success of our initiatives depended on the collaborative spirit of my fellow CWTS members, the daycare staff, the children, and their parents. This collective action is essential for fostering a supportive and engaged community, demonstrating that every individual's contribution is vital to achieving common goals."

> "This experience highlighted the importance of communal support systems and the role of each individual in maintaining these networks."
>
> "I firmly believe that good governance is pivotal in shaping not just my future but the collective destiny of our society. By choosing wisely, I am advocating for my interests and championing the well-being of others and the community as a whole."

This insight highlights how cadets' prior notions were re-examined in light of their field experiences, resulting in a deeper and more critical understanding of community realities.

5.4. Active Experimentation

In the final stage of Kolb's framework, cadets planned how to apply their new knowledge in future settings. They expressed commitments to continued engagement in volunteerism and public service. Cadets wrote:

> "I can continue to apply these lessons by staying engaged in community service activities and advocating for educational programs. Volunteering in local schools, participating in community cleanups, and promoting environmental sustainability are ways I plan to extend the impact of my CWTS experience."
>
> "I will continue to engage in community service, using my knowledge and skills to help others. I aspire to stay involved in community work, offering support and making a positive difference wherever possible."

Others focused on educating younger family members or mentoring youth:

> "I can apply these lessons even in the real world by starting with my younger siblings. Once I'm reunited with them, I'll tell them about my experiences with CWTS and the lessons I gained."
>
> "I'll mentor young individuals, amplifying their voices for a more inclusive society."

Cadets also reflected on the need to address systemic issues and promote long-term change:

> "I will mentor and empower young people to become agents of change in their communities, inspiring them to take action and positively impact the world around them."
>
> "I plan to participate in local community projects, advocate for better educational resources, and promote health awareness campaigns."
>
> "I will continue to engage in lifelong learning, seeking opportunities to deepen my understanding of environmental sustainability, disaster risk reduction, and public health. I will actively participate in community engagement efforts, advocating for local, national, and global policies and practices that promote sustainability, resilience, and public health."

These reflections suggest that experiential learning motivated cadets to remain socially engaged beyond the program's scope.

The discussion aligns with Kolb's four-stage framework and demonstrates how cadets progressed from experience to reflection, concept formation, and future application. The development of teamwork, communication, patience, and leadership echoed findings by Leal Rodriguez et al. (2019), Payne et al. (2001), and Marasi (2019), which support the value of team-based, action-oriented learning. Comer et al. (2014) and Peterson et al. (2004) noted that patience is crucial in interpersonal growth and community engagement.

Experiences encountered during the CWTS program challenged cadets' assumptions and led to broader social awareness. This reflects Roland's (2016) view that experiential learning provides deeper and more meaningful understanding beyond textbook theories. As Teneja et al. (2022) pointed

out, experiential learning allows students to translate knowledge into action and sustain it in real-world settings.

6. CONCLUDING REMARKS AND RECOMMENDATIONS

In these changing times, where overlapping crises affect various dimensions of life, including the influence of capitalism, education continues to serve as a powerful tool in preparing learners to become future professionals and leaders. These individuals must possess the head, heart, and hand to respond to environmental and societal challenges across multiple levels. The experiences of CWTS cadets who participated in the "Start 'em Young Advocacy" illustrate the transformative role of experiential learning. Their reflections show how such learning develops skills, encourages critical understanding, and strengthens personal convictions that can translate into present and future actions.

The analysis of cadet reflections, interpreted through Kolb's Experiential Learning Framework, aligns with the goals of the NSTP Act, which aims to "inculcate in the youth patriotism, nationalism, and advance their involvement in public and civic affairs." It also supports Silliman University's mission to promote "total human development for the well-being of society and environment."

Experiential learning plays a central role in this process. The community, or the city, has a significant function in experiential learning, as observed by Kolb et al. (2005), Beard et al. (2006), and Hassink et al. (2012), who argued that learning occurs beyond the classroom and through participation in contextualized social realities. Learning emerges from relationships among individuals, institutions, social meanings, sociopolitical conditions, and systems (Freeman, 2006). Within this context, individuals act as reflective practitioners who draw lessons from complex situations that respond and evolve (Schön, 1991). Institutions influence behavior and contribute to collective learning by shaping social environments (Pelling et al., 2008).

This process also involves interpreting social meanings, recognizing implied knowledge and assumptions (Fischer and Mandell, 2012), and engaging in sociopolitical contexts where values and goals are subject to ongoing negotiation (Hall, 1993). Systems help create the conditions that support learning and transformation, both individually and collectively (Schön, 1973; Loeber et al., 2009; Macintyre et al., 2018).

These dynamics were evident in the learning experiences of CWTS cadets, shaped by their interactions with institutions such as the university, local government units, and barangay-level systems. Although this study demonstrated that students gained valuable insights through their community-based experiences, it did not fully explain how cities, as learning environments, influenced their learning process. The absence of this clarity presents an opportunity for further research to identify and examine specific urban characteristics that contribute to experiential learning.

Other recommendations include:

a) Obtain consent from students before using class outputs such as reflection papers or audiovisual submissions as data for research that aims to improve teaching and learning.
b) Specify the expected learning outcomes based on the study's findings. Activities and assessments should be aligned with Kolb's Experiential Learning Framework and designed to support experience-based objectives.
c) Hold multiple reflection sessions during the program to better capture student learning and developmental progress.
d) Explore how student involvement in community-based experiences benefits community stakeholders. This line of inquiry would emphasize the reciprocal and multi-actor nature of experiential learning.

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PARTICIPATORY EXHIBITIONS AS AN AWARENESS-RAISING PLATFORM FOR BIRD-WINDOW COLLISIONS

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ABSTRACT

Bird window strikes pose a significant threat to avian populations in urban settings. Understanding public attitudes toward this issue is vital for communicating the problem and possible interventions, such as applying window stickers. Bird Window Strike Philippines, a citizen science initiative, has promoted awareness through online engagement and a public pop-up exhibition designed to leave a lasting impression and gather visitor feedback. The exhibition introduced Filipino audiences to bird-window collisions through educational and participatory elements, including interpretive panels, taxidermied bird specimens, and window models demonstrating prevention techniques. Its central message was: "Bird window strikes are a problem, and we can be part of the solution." The taxidermied birds were included to foster emotional connection. Visitors participated by voting on preferred preventive measures and answering questions about what would encourage them to adopt these interventions. Comment cards captured their reflections and takeaways. Results showed a clear preference for window stickers and mesh and a desire for affordable and accessible options. Notably, emotional engagement was evident among participants, reflecting the exhibition's capacity to foster empathy and deeper reflection. Open-ended responses highlighted key themes: human agency in mitigating collisions, the conservation significance of window strikes, the role of citizen science and public awareness, and the underestimated frequency of such events. The exhibition served to raise awareness of this often-overlooked conservation issue. The study supports public exhibitions as effective tools for fostering dialogue and building biodiversity-inclusive urban environments.

Keywords: Bird-friendly design; Bird window strike; Science communication; Urban biodiversity

1. INTRODUCTION

Anthropogenic activities across the globe are contributing to a significant decline in biodiversity (Snep et al., 2016). Among the major drivers is global land use change, with urban and built-up areas doubling since 1992 (Watson et al., 2019). While well-planned urban development can help maintain contiguous habitats within cities, it is also important to ensure that wildlife can navigate safely through these complex landscapes (Farinha-Marques et al., 2011). Integrating biodiversity-friendly design into cities to invite bird life must be cautiously approached, as the built environment poses various threats to birds (Snep et al., 2016).

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Window strikes are among the leading causes of bird mortality in urban areas, with estimates of up to a billion bird deaths annually in the United States (Kornreich et al., 2024; Loss et al., 2014, 2023), 7.65 million in South Korea (C.-M. Kim et al., 2023), and 25 million in Canada (Machtans et al., 2013). As of 2020, most studies on bird-window collisions have originated in North America, yet the threat may be significantly underreported in tropical countries where bird diversity is highest (Basilio et al., 2020). In Southeast Asia, research on bird-window collisions remains limited, with citizen science reporting platforms currently present in Singapore (Tan et al., 2018, 2024), Taiwan (Hsieh et al., 2024), and the Philippines (Ramos & Gan, 2024).

Urban development and proximity to bird habitats are key contributors to window collisions (Hager et al., 2017; Tan et al., 2024). Cities such as Metropolitan Manila are projected to continue expanding rapidly (Baloloy et al., 2019; Estoque, 2017; Iizuka et al., 2017; Ortega, 2014; Patiño et al., 2019; Taubenböck et al., 2012), driven by increasing land value, socio-political pressure tied to economic interests, globalization, and a fast-growing middle-class population (Daguio et al., 2021; Ortega, 2012). This urban sprawl often replaces vegetation and green spaces in peri-urban and densely built-up areas (Estoque, 2017; Murakami &Palijon, 2005; Ortega, 2014).

Bird Window Strike Philippines (BWSPH) collects citizen science reports of bird-window collisions via Facebook. Between 2013 and 2023, the program gathered 296 collision reports involving 71 species across 32 bird families (Ramos & Gan, 2024). This number likely underrepresents the true extent of the issue, as about 25% of collisions go undetected without intensive and continuous monitoring (Klem Jr, 2009). Furthermore, large and colorful species tend to be reported more frequently than smaller, dull-colored birds (Tan et al., 2018). The reports show a high mortality rate of 67% (Ramos & Gan, 2024), reinforcing the urgency of prevention to avoid death and severe injury (Kornreich et al., 2024; Loss et al., 2014; Tan et al., 2018).

Birds often fly into the glass because they perceive reflections of habitat or see through to potential shelter (Klem, 2006; Martin, 2011). Nearby vegetation and food sources increase the risk of these collisions (Brown et al., 2019, 2021; Ramos & Gan, 2024). Disrupting the reflected image helps birds recognize glass as a solid barrier. Prevention methods such as ceramic frit patterns, evenly spaced decals, and one-way films have been studied by Klem Jr (2009), who recommended a maximum five-centimeter spacing between opaque elements to make glass surfaces visible to birds. Martin (2011) proposed using high-contrast black-and-white patterns to accommodate avian visual systems under various light conditions. Over time, both commercial and homemade solutions have followed these principles. These include hanging vertical cords, evenly spaced decals, vertical lines, mesh or screens on the exterior surface, and decorative stickers in natural shapes like raptors, flowers, or butterflies. All these methods help disrupt the reflection and make the glass surface more apparent, though their effectiveness depends on spacing and contrast. Field observations have shown that collisions decrease significantly when such measures are applied (Brown et al., 2019, 2021; Ocampo-Peñuela et al., 2016).

Although guidelines and policies promoting bird-friendly design are emerging, they are not yet widely adopted (Bird-Safe Design Guidelines, 2020; Carley & Klem Jr, 2016; Hyun-soo, 2023). Moreover, stringent standards for effective prevention may discourage homeowners who perceive these measures as obstructive or inconvenient (Menacho-Odio, 2018; Schultz, 2011; Warren, 2013). Public preferences regarding prevention tools can influence how behavioral interventions are implemented at a community level. Understanding behavioral drivers is critical to mitigating the impact of urban environments on birds (Riggs et al., 2022; Snep et al., 2016). Only three studies have investigated the behavioral factors that influence the installation of preventive measures, including awareness and financial incentives (Loss et al., 2023; Menacho-Odio, 2018; Riggs et al., 2022; Warren, 2013). Understanding stakeholders' preferences can support the development of urban policies that reflect community priorities.

Given the growing need for public engagement tools to address conservation issues, this study demonstratesthe use of an exhibition to communicate the work of BWSPH through a participatory space where visitors could share their insights on bird-window collisions. By examining responses from exhibition participants, the study also explored communication strategies and framing that may support BWSPH's future outreach efforts.

2. LITERATURE STUDY

2.1. Communication Platforms for Bird Window Collisions

Bird window research groups, such as FLAP Canada, the American Bird Conservancy, the Bird Collisions Prevention Association (in Korea), and the authors' own Bird Window Strike PH (BWSPH), use online communication platforms for their education and awareness programs. Although online engagements have their strengths, the experience of seeing and interacting with physical installations can increase awareness by forming lasting memories and supporting information retention (Falk, 2022; Rios & Negrete, 2013).

People can learn and develop lasting and emotionally meaningful shared memories in spaces such as museums (Falk, 2022). For educational materials not included in traditional schooling systems, museums—defined here to encompass traditional museums, zoos, botanic gardens, and temporary installations—can help address educational gaps (Falk & Dierking, 2018; Solis et al., 2021). Notable examples of bird window strike exhibitions include FLAP Canada's Annual Bird Layout of birds that died after colliding into windows (FLAP Canada Data – FLAP Canada, n.d.); Impact by Minneapolis artist Miranda Brandon (Ebersole, 2015); and Bird Window Collision (Yuchen, 2023; Yuting, 2023), held at the Caoshan (Grass Mountain) Raptor Center by the Taiwan Raptor Research Society.

2.2. Behavior Change Approaches and Communication Strategies

In the Philippines, the museum concept has shifted from a static repository of objects to a more interactive institution (Labrador, 2015; The Mind Museum, Taguig, Philippines | Science Comes Alive, n.d.). In a Philippine handbook for establishing museums, Villafranca and Rodrigo (2017) emphasize the evolving role of museum exhibitions as catalysts for social change. An exhibition about bird-window collisions in the Philippines is timely in light of this transformation and the urgent need to prevent bird collisions.

Solutions to environmental challenges, including bird-window collisions, depend on human actions and require a shift in behavior (Schultz, 2011; Steg &Vlek, 2009). Behavior change theories and frameworks, such as the Behavior Change Wheel (Michie et al., 2011), the Behavior Drivers Model (Dekens et al., 2024; Petit, 2019), behavioral nudges (Thaler & Sunstein, 2021; The Little Book of Green Nudges: 40 Nudges to Spark Sustainable Behaviour on Campus, 2020), and Community-Based Social Marketing (McKenzie-Mohr, 2011), have been applied to various pro-environmental behaviors. These models help identify values, attitudes, and contextual factors that support lasting behavior change using approaches such as choice architecture and message framing.

Emotions are essential in science communication (Davies et al., 2019), especially for conservation messages (Williamson & Thulin, 2021). Emotional reactions can serve several functions, such as generating curiosity about complex or unfamiliar topics (Williamson & Thulin, 2021). Although positive emotions are often recommended in framing pro-environmental behavior (Ainsworth & Burns, 2020), negative emotions may also contribute to increased concern and willingness to take action (Wong-Parodi&Feygina, 2021). Informed by behavioral theory and emotional framing, the exhibition was intentionally designed to elicit affective responses that could drive awareness and action.

2.3. Participatory Exhibitions

Modern museums have regarding bird-window collision prevention, Menacho-Odio (2018) organized an exhibition of sample prevention strategies at a local library. Respondents ranked their preferences from highest to lowest: hanging cords, mesh, vertical lines, and a grid of decals. These methods were favored because they do not obstruct the view, are visually appealing, and are perceived to be effective in reducing collisions.

The study presented in this paper adopted similar participatory components in an exhibition aimed at gathering community perspectives on bird-window collisions and potential solutions. The exhibition targeted a broad audience, intending to raise awareness among individuals with limited prior interest, deepen understanding, and offer actionable strategies to those familiar with the issue (Longnecker, 2023). The researchers examined which prevention methods Filipino audiences found appealing, which factors they considered when installing preventive measures at home, and which aspects of the exhibition regarding bird-window collisions left a lasting impression.

3. METHODS

A pop-up exhibition was developed to present Bird Window Strike Philippines (BWSPH) research findings, which has been collecting reports since 2020. The exhibition featured panels, taxidermied birds that died from strikes, and interactive elements to engage the public and collect feedback on prevention strategies (see Figure 1A), and participatory elements designed to gather community insights on bird-window collisions and possible prevention strategies. The use of dead birds as part of an emotionally vivid communication approach has also been adopted by other bird-window strike research groups (Brown et al., 2019), as it can make the message more emotionally impactful and enhance its reception (Blondé&Girandola, 2016). The exhibition took place in the lobby of the Institute of Biology at the University of the Philippines Diliman, located in Quezon City. A small-scale exhibition allows visitors to view the entire layout and choose how to navigate the displays (Serrell, 2015).

The central message of the exhibition was: “Bird window strikes are an issue, and we can be part of the solution.” This message was divided into three supporting ideas, which shaped the content of the exhibition: (i) birds collide with windows more frequently than we expect; (ii) many species are affected, and some more than others; (iii) prevention solutions exist, and individuals can help reduce collisions by applying them to their windows.

The didactic panels displayed the research findings of BWSPH, including explanations of why birds collide with glass, which species are most commonly affected, and typical injuries and causes of death based on the literature. The scale and species diversity of collision incidents, including those involving threatened species, were also presented to emphasize the seriousness of the problem. One panel featured a map of reported bird collisions across the Philippines to illustrate the nationwide scope of the issue. All didactic panels were presented in both English and Filipino. They used minimal text and emphasized visuals such as diagrams and photographs, as recommended by Serrell (2015) (see Figure 1B).

Figure 1 (A) Visitor a Display with with taxidermied birds killed by window strikes. (B)Results of window collision research were presented with a clear hierarchy of ideas and chunking of text for easier reading and comprehension.

Two of the participatory elements in the exhibition involved the use of drop box sets. The first set (Figure 2) displayed sample windows with bird-window collision prevention measures and invited visitors to vote by placing a token in the drop box corresponding to their preferred prevention method. The four solutions presented were: bird-shaped stickers, square decals from Birdgard, hanging ropes based on AcopianBirdsavers specifications using dark-colored paracord spaced 2.9 centimeters apart (Make Your Own (DIY) AcopianBirdsavers, n.d.), and a mesh fitted to the outer frame of the glass. Bird-shaped stickers and hanging ropes were included based on Menacho-Odio (2018), while square decals and mesh were added because they are prevention methods that are locally accessible.

Figure 2 Sample Window Collision Prevention Methods were Presented, and Visitors could Use a Token to Vote in a Drop Box to Indicate Their Preferred Method

The second part of the participatory exhibit (Figure 3A) featured a panel asking visitors what they believed would motivate them to use collision prevention methods in their homes. Their responses were recorded by placing a token into one of four drop boxes, with all options presented in both English and Filipino: (i) I want more information about different kinds of collision prevention solutions. (*Gusto ko pa ng iba pang impormasyon tungkol sa mga solusyon sa pagsalpok ng mga ibon sa bintana.*); (ii) I want more affordable solutions. (*Gusto ko ng mas abot-kaya na solusyon.*); (iii)I want to know if my friends or family also use the solutions. (G*usto kong malaman kung mayroon sa aking mga kaibigan at kamag-anak ang gumagamit ng mga solusyon na ito*.); (iv) I want help installing the solutions. (*Kailangan ko ng tulong para ilagay ang mga solusyon na ito.)*

A notepad and a fifth drop box were provided for visitors to write down any other reasons not listed on the panel (Figure 3A). To differentiate responses from minors (under 18 years old), clear tokens were given to adults and orange tokens to minors in both sets of drop boxes. Responses from individuals aged 18 or younger were excluded from the study results due to ethics clearance requirements. However, their inputs were still documented, as these insights remain relevant for future BWSPH communication planning.

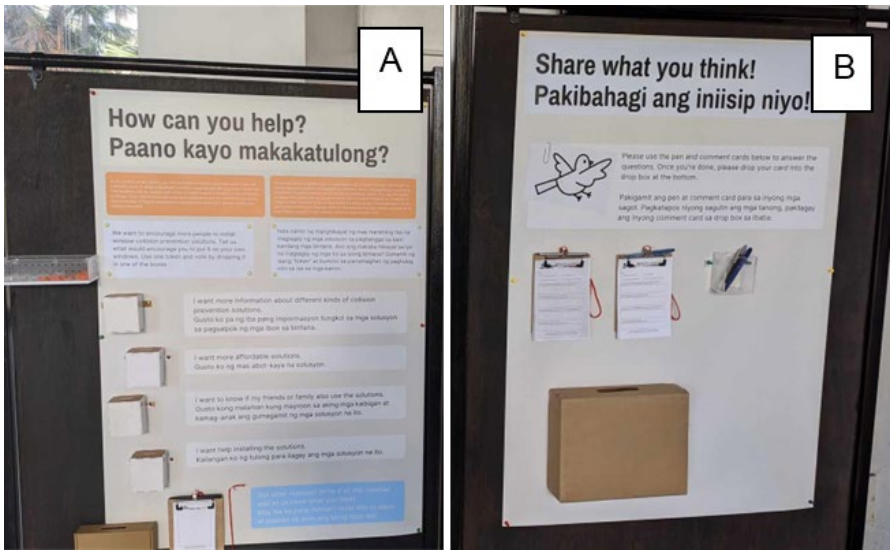

Figure 3 (A) In this panel, visitors could use a token to indicate which factor would most likely encourage them to use a collision prevention method in their home. (B)In this exhibit, visitors could fill out comment cards to share their insights. Photo by Gerard Que

A third participatory panel invited visitors to fill in a comment card to share their thoughts about the exhibit and window collisions (Figure 3B). The comment card included the following questions: (i) What is one thing that you learned from the exhibition? (Ano ang isang bagay na natutunan mo sa tanghalan na ito?); (ii) What is something from the exhibition that you will share with your friends and family? (Ano ang natutunan mo dito na ibabahagi mo sa iyong mga kaibigan at pamilya?); (iii) Anything else you want to let us know? (Iba pang mga bagay na gusto mong ipaalam sa amin?)

Because many visitors may feel reluctant to write extended comments, an additional, simple question was added to increase participation: What three words would you use to describe how you felt about this exhibition? (Gamit ng tatlong salita, ano ang naramdaman mo dahil sa tanghalan na ito?)

This “what three words” question has been used to improve visitor response rates at events and displays and to gather immediate, instinctive reactions (Longnecker et al., 2014; Solis et al., 2021).

The exhibition was open on weekdays from February 6 to 16, 2024. Visitor foot traffic was monitored on five exhibition days through direct observation (Figures 4A and B), with a visitor defined as someone who stayed at any panel for at least 10 seconds or physically interacted with any participatory element. Passers-by were excluded. Tokens in drop boxes and comment cards were

collected every two to three days. At the end of the exhibition, all tokens from drop boxes were counted.

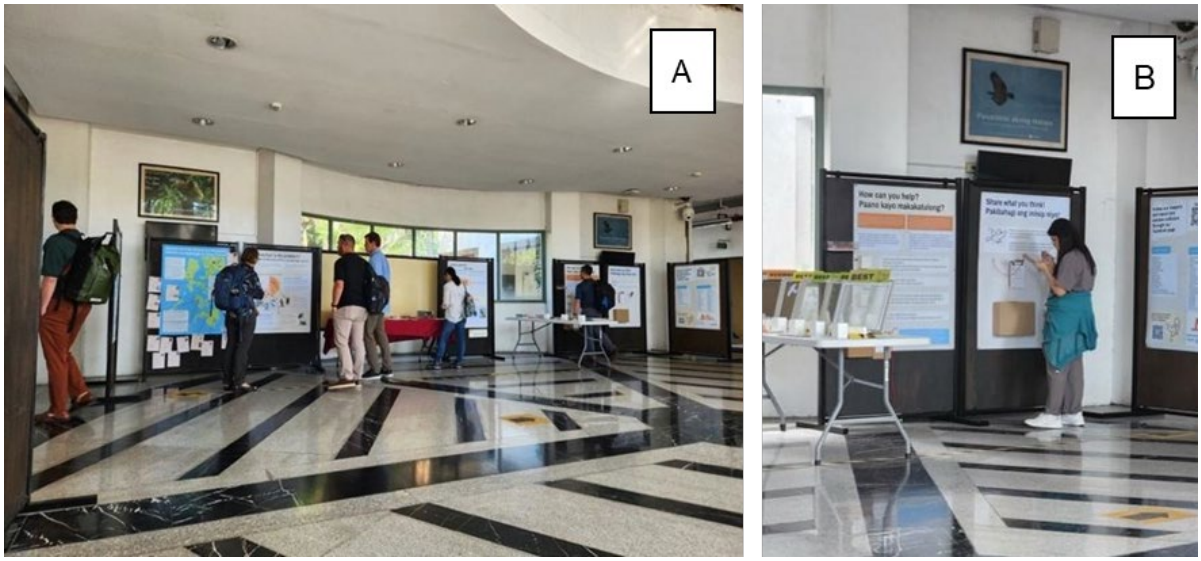

Figure 4 (A) Visitor foot traffic was counted directly, observing the duration and interaction of visitors with the exhibition. (B) Participatory elements in the exhibition allowed visitors to share their insights

Answer to the open-ended questions were transcribed for reflexive thematic analysis. All responses submitted in Filipino were translated into English for coding and reporting. The study used an inductive approach that involved identifying main ideas from the answers and assigning codes accordingly. These codes helped reveal patterns or themes of meaning and common ideas across the qualitative data. The reflexive aspect of this thematic analysis made it possible for the researchers to remain critically aware of their own perspectives and experiences, which supported theoretical flexibility and allowed themes to emerge inductively from the content, as Braun and Clarke (2021) recommended.

The first author (JCC) reviewed the responses multiple times before drafting a list of themes. These were discussed with other communication researchers, and the responses were grouped into the following themes: Solutions and Agency (solutions to collisions exist, and humans are responsible), Conservation (window collisions are a conservation concern), Reporting (awareness and citizen scientist reports can help address collisions), Frequency (collisions occur more often than expected), and Exhibition Feature (memorable features of the exhibition). The frequency of each theme among visitor responses was reported to reflect how frequently each idea appeared (Braun and Clarke, 2022).

The same process was applied to explore the descriptors given in response to the question, “What three words would you use to describe how you felt about this exhibition?” This generated the following themes, presented in Table 1: (i) Upset (descriptors expressing negative emotions); (ii) Optimism (descriptors expressing positive emotions); (iii) Informed (descriptors related to knowledge or curiosity); (iv) Empathy (descriptors showing compassion or emotional connection)

These themes helped provide an overall sense of how visitors responded emotionally to the exhibition. A word cloud was created using https://simplewordcloud.com to present the range of descriptors visually.

4. RESULTS AND DISCUSSION

Over 500 people visited the exhibition during the nine days, averaging 56 daily visitors. While not

all visitors engaged with the participatory elements, those who did (approximately 36%) contributed valuable insights. In the panel that asked for preferences regarding bird-window collision prevention (Figure 5A), visitors aged 18 and above showed the highest preference for square decals (n = 84) and mesh (n = 58), followed by hanging ropes (n = 28) and bird-shaped decals (n = 10). The first three window samples were labeled "Best" while the bird-shaped decals were labeled "Better" This labeling may have influenced how visitors cast their votes.

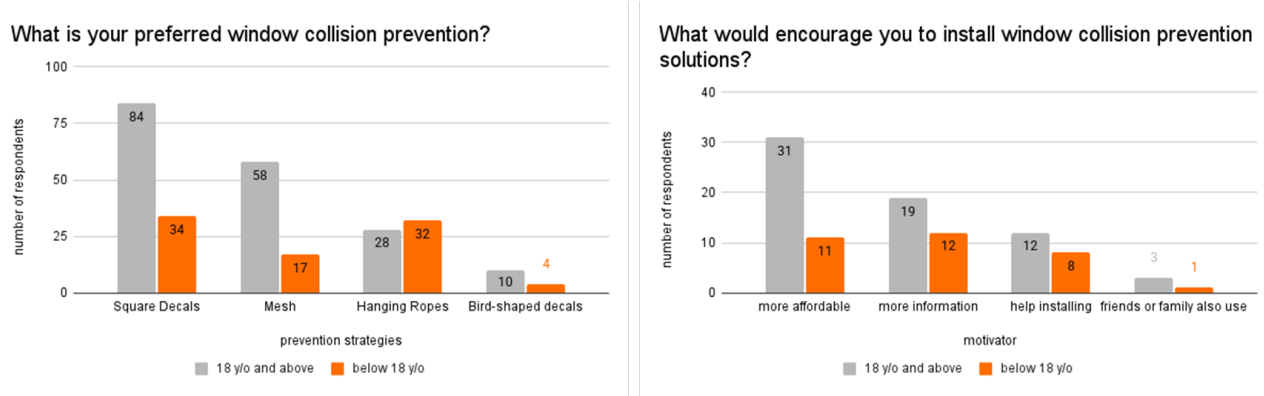

Figure 5 Visitor Response to the Interactive Elements of the exhibit. (A) Responses to the question "What is your Preferred Window Collision Prevention?" (B) Responding to the Question, "What would encourage you to install window collision prevention solutions?"

In comparison, Menacho-Odio (2018) reported that the Costa Rican community ranked their preferences from highest to lowest as cords, mesh, lines, and dots. Their respondents noted that these options do not obstruct the view, are visually appealing, and are considered effective against collisions. Unlike Menacho-Odio's study, this exhibition did not ask visitors to explain why they preferred particular prevention methods. This could be explored further in future exhibitions.

In the panel asking, "What would encourage you to install window collision prevention solutions?", visitors aged 18 and above most frequently selected more affordable options, followed by a need for more information and help with installation (Figure 5B). Few participants selected the influence of friends or family as a motivating factor. However, even if individuals do not consciously recognize the influence of others' behavior, normative factors can still serve as powerful drivers of behavior (Balderjahn&Appenfeller, 2023; Y. Kim, 2023; Nolan et al., 2008). Normative messages can rely on either direct observation or descriptions of other people engaging in the desired behavior.

In the open-ended section of this panel, one visitor suggested working more closely with architects to develop solutions suited to different settings. For instance, they cited the need for alternatives to hanging ropes in high-rise buildings, where wind conditions make them unsafe. They also proposed using sun baffles or brise-soleil, which serve as architectural cooling features and as a way to break up glass reflections. This and similar suggestions point to a segment of visitors who strongly understand the window collision issue and view it through a system or policy-based lens.

The interest in affordable options and access to more information is consistent with the findings of Riggs et al. (2022), where homeowners expressed support for and interest in installing collision prevention. Menacho-Odio (2018) and Riggs et al. (2022) recommend targeted education about the scope of bird-window collisions and available solutions. However, these studies do not suggest how messages can be framed or tailored to different audiences. Furthermore, support for pro-environmental behavior does not always lead to corresponding action (MacDonald et al., 2019).

The recommendations by Menacho-Odio (2018), Riggs et al. (2022), and Warren (2013) follow a traditional conservation communication model: "think–care–act." This assumes stakeholders will adopt pro-conservation behavior when provided with knowledge and an emotional reason. Designing

effective interventions requires attention to the broader social context and paradigms influencing behavior (Klebl et al., 2024; Longnecker, 2016; Petit, 2019). Addressing external factors can help in framing the following questions relevant to this case study: (i) Do people have control over the options? (Are they homeowners? Should messages target specific audience segments?); (ii) Do people require support or skill-building to apply the solutions? (As suggested by the top three motivations reported.); (iii) Would social norms support the behavior? (Would installing preventions be seen as unusual, reducing the likelihood of uptake?).

Examining window collisions through a systems-thinking perspective allows for a more nuanced understanding of human ecology (Meadows, 2009). This approach can help identify root causes and challenge dominant paradigms, making room for transformational change (Van Eeden et al., 2024). With increasing tension between infrastructure and natural ecosystems, adopting a pluralistic and interdisciplinary lens is essential for conservation efforts (Gardner et al., 2009).

Twenty comment cards were submitted at the final participatory panel by visitors aged 18 and above, accounting for approximately 4% of exhibition attendees. Five of these responses came from homeowners. In response to the question, “What three words would you use to describe how you felt about this exhibition?”, not all respondents provided exactly three words. Instead, some gave a combination of words and phrases. These were processed into 53 descriptors, and longer phrases were condensed into single words. For example, “Eager to know more” was included as “curious”, and “Malungkotdahil maraming ibong namamatay dahil sa bintana” (sad because many birds die due to windows) was merged with “sad” The responses yielded 28 unique words, which were visualized as a word cloud. These were categorized into the following themes: Upset, Optimistic, Informed, and Empathy (Table 1). A fifth category, Exhibit Description (relating to comments on the exhibition's format or quality), was identified but excluded from emotional analysis as it did not reflect emotional reactions to the exhibit.

Table 1 Descriptions of emotions expressed by visitors, with examples from responses to the question, ‘What three words would you use to describe how you felt about this exhibition?

Theme	Description	Number of Respondents	Examples of Words from Answer
Upset	Generally negatively-associated emotions	16	Surprised, sad, angered, worried, pity
Informative	Any descriptor that was knowledge-based or concerned with curiosity	24	Simple and clear, easily understandable, curious
Optimistic	Generally positive emotions	5	Helpful, hopeful
Empathy	For descriptors that are compassion-related	2	Eco-sensitivity, compassion

A word cloud was generated to visually represent visitor responses to the “What three words?” question (Figure 6). The most frequently mentioned descriptors were sad (n = 10), informative (n = 5), eye-opening (n = 4), enlightened (n = 3), curious (n = 3), hopeful (n = 2), shocked (n = 2), and amazed (n = 2).

Figure 5 The Word Cloud Visualization of Visitor Responses (n=53) to the question: 'What Three Words Would You Use to Describe How You Felt About this Exhibition?'. The Size of Each Word is Proportional to Its Frequency in Responses. It Was Created Using https://simplewordcloud.com/

Sadness emerged as the most common emotion expressed by visitors. This emotion may arise from a sense of connection to nature and feelings of grief when faced with environmental loss (Ainsworth & Burns, 2020). Other emotions, such as anger, may serve as a means for individuals to confront or challenge others (Williamson & Thulin, 2021). In the context of window collisions, such emotions may lead people to discuss the issue with friends and family, particularly those working in fields like architecture and urban planning. Messages that combine strong emotional content with themes of human responsibility and practical solutions can increase public engagement (Ainsworth & Burns, 2020).

Descriptors such as curious, eye-opening, and informative suggest that visitors expressed interest in the issue of window collisions. Interest is an important driver for seeking information on unfamiliar and complex topics (Williamson & Thulin, 2021) and can influence whether or not individuals engage with new knowledge (Longnecker, 2016). This makes interest a valuable entry point for raising awareness about relatively new conservation challenges like bird-window collisions. Although less frequent, emotions such as hope and optimism also appeared in visitor responses. Hope can support motivation to adopt new behaviors, especially when people are presented with solutions to threats affecting something they value (Williamson & Thulin, 2021). Emotional responses captured on the comment cards indicate that the exhibition succeeded in evoking reactions that can support memory retention and may contribute to behavior change in support of environmental goals (Ainsworth & Burns, 2020; Williamson & Thulin, 2021; Wong-Parodi&Feygina, 2021).

Lastly, Table 2 presents themes derived from combined responses to two open-ended questions: "What is one thing that you learned from the exhibition?" and "What is something from the exhibition that you will share with your friends and family?" Responses classified under the themes Solutions & Agency and Frequency correspond to two key sub-messages in the exhibition:

1: "Birds collide into windows more often than we think."

3: "Prevention solutions exist, and you can help prevent bird strikes by putting them on your windows."

These findings indicate that visitors understood the main messages conveyed through the exhibition and gained insights into the importance of citizen science and the impact of window collisions on bird conservation. One visitor mentioned they intended to talk about the taxidermied birds with their friends and family.

Table 2 Theme descriptions and examples from answers to the questions: "What is one thing that you learned from the exhibition?" and "What is something from the exhibition that you will share with your friends and family?"

Theme	Description	Number of Respondents	Examples of Words from Answer
Solutions & Agency	Solutions to collisions exist, and humans are responsible	18	Possible solutions/modifications to windows That they [collisions] can be prevented by planning I will share the importance of considering the other animals around us when we construct houses/buildings. A little more compassion for animals could make the world a better place!
Conservation	Window collisions are a conservation concern	7	Bird strikesare a real and pressing problem and a significant threat to birds Window strikes and how window designs are relevant to the survival of birds
Reporting	Awareness and citizen scientist reports can help solve collisions	7	Windows are not always good. You can help by reporting window strikes People are willing to participate in Citizen Science Reporting
Frequency	Collisions happen more often than we think	4	I learned that bird-window collisions happen more often than we think. It's quite alarming. How underreported the phenomena is. Even I did now know much or hear much about it until today despite connections to people [in the field of Biology]
Notable features	Notable features of the exhibition	1	Taxidermied birds

Framing environmental issues to highlight human agency and to show how both social and personal responsibility contribute to solutions is important in environmental advocacy messaging (Campbell, 2014). One possible reason for the effectiveness of this exhibition is that bird collisions were presented as an issue with clear and achievable solutions.

Future versions of this exhibition could include prompts that ask visitors to reflect on their roles in preventing window collisions. These questions could include: What is my role in preventing window collisions? What can my friends and family do to help prevent window collisions? Who are members of my community that can help prevent window collisions? When displayed in a public setting, these questions may encourage reflection, personal ability to act, community connection, and willingness to participate (Petit, 2019).

Future research on stakeholder perceptions of bird-window collisions could examine why certain prevention methods are preferred. It could also explore whether those preferences remain the same when factors such as financial cost, installation complexity, and structural fit are introduced. Because behavior and decisions are influenced by values, social norms, mental models, and emotional responses (Longnecker, 2016), these factors may help explain how people approach prevention methods at home.

To understand different audience groups, latent class analysis could help identify clusters of individuals within a population. These can be used to design communication strategies for specific types of stakeholders (Hine et al., 2014). Behavior change frameworks such as the Stage Model of Behavior Change (Bamberg, 2013; Klöckner, 2015, 2017; Klöckner & Richter, 2022) and the Behavioral Drivers Model (Petit, 2019) can also be

applied to this issue to support the development of more complete behavior interventions (Loss et al., 2023; Schultz, 2011; Steg &Vlek, 2009).

Human decisions shape the future of urban biodiversity (McCloy et al., 2024). A better understanding of these decisions and preferences can influence how urban planning and management address the effects of rapid urbanization on bird populations, especially in Philippine cities (Estoque et al., 2018).

5. CONCLUSION

This study demonstrates that participatory museum exhibitions are effective platforms for raising awareness about bird-window collisions and engaging the public in conservation dialogue. By creating a space where visitors can learn and express their views, the exhibition contributed to conservation education. The dropboxes made it possible to gather visitor preferences and explore what might influence their decision to adopt prevention methods at home. Responses to the open-ended questions suggest that the exhibition conveyed its core messages clearly and prompted deeper thinking about bird collisions and the value of citizen science. Exhibitions like this can support communication about conservation and offer a way to gather insights for making cities more biodiversity-inclusive.

6. ACKNOWLEDGMENT

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BARRIERS TO LEARNING EXPOSURE IN CONSTRUCTION 4.0: PERSPECTIVES FROM BUILT-ENVIRONMENT STUDENTS

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ABSTRACT

The ongoing digital transformation of the construction industry, known as Construction 4.0, requires students in built-environment programs to gain adequate exposure to emerging technologies. Despite this need, many faces significant barriers to meaningful engagement. This study explores the factors limiting students' learning experiences related to Construction 4.0 in Nigerian universities and polytechnics. Using a stratified random sampling method, 154 students from one university and one polytechnic were surveyed through a structured questionnaire. Data were analyzed using frequency distribution, relative importance index, and the Mann-Whitney test. Results identify key obstacles such as limited peer collaboration, insufficient funding and resources, and weak infrastructure. There were no statistically significant differences in these barriers between university and polytechnic respondents. The study concludes that addressing the current limitations requires institutional reforms, including infrastructure investment, curriculum development, faculty training, and support for student collaboration, particularly in polytechnic settings.

Keywords: Barriers, Built Environment, Construction 4.0, Curriculum, Expectation, Measures

1. INTRODUCTION

The integration of Industry 4.0 into the construction sector has expanded rapidly due to the potential of digital technologies to improve project performance and management processes. Beyond its application in manufacturing, Construction 4.0 introduces transformative changes across various sectors (Kozlovska et al., 2021). Adopting smart and digital tools has led to better construction outcomes by reducing project timelines and costs, minimizing defects, and improving safety and client satisfaction. Technologies such as augmented and virtual reality contribute to these improvements across the project lifecycle (Albahbah et al., 2021). The construction industry relies on innovation as a key driver of infrastructure and economic growth. A limited focus on research and development in Construction 4.0 may weaken the curriculum in built-environment programs and restrict technological progress (Ravald, 2021; Ammar et al., 2022).

Curriculum development forms the foundation for institutional planning, course evaluation, and student academic progression. It shapes learning outcomes, informs teaching practices, and strengthens institutional management (Dhanapala, 2021). A well-designed curriculum enhances academic quality, integrates learning resources, and promotes collaboration among students, faculty, and administrators (Fatoni et al., 2024).

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Incorporating key Industry 4.0 competencies, such as Building Information Modeling (BIM), artificial intelligence, big data, and immersive technologies, requires a systematic approach to curriculum design. These competencies help students comprehensively understand construction engineering and its evolving digital tools (Alhamami et al., 2020).

Construction 4.0 calls for early exposure to digital innovation within educational settings. Future graduates need hands-on experience that reflects industry changes and aligns with global trends (Shuhaimi et al., 2022). Advancing institutional readiness for Construction 4.0 involves updating curricula to reflect current technologies and build stronger links between construction education and related disciplines (Alenezi, 2023). However, research has pointed to existing limitations in curriculum content, delivery methods, student engagement, and collaborative learning, particularly within built-environment programs (Amusan & Aigbavbov, 2020; Giesenbauer, 2020).

Regular curriculum reviews are necessary to strengthen student interest in Construction 4.0. Although this topic has received scholarly attention (Forcael et al., 2020), gaps remain regarding exposure, teaching delivery, and future readiness. As a relatively new area in higher education, particularly in Nigeria, little research has explored how Construction 4.0 is implemented in the curricula of built-environment programs. This study addresses that gap by investigating the barriers that affect student learning exposure. The research objective is to identify the barriers hindering the learning exposure of built-environment students to Construction 4.0. The study also tests the hypothesis that there is no significant difference in the barriers influencing student exposure across built-environment programs.

2. LITERATURE STUDY

2.1 Construction 4.0 in Education

The Fourth Industrial Revolution (Industry 4.0) is transforming the construction industry and introducing the era of intelligent construction. Technological innovations such as the Internet of Things, big data, cloud computing, and artificial intelligence have been integrated into all stages of the building lifecycle and play an important role (Feng, 2020). These technologies have been increasingly applied across various aspects of the construction sector in recent years to support project execution, resource planning, performance analysis, risk assessment, and design enhancement.

Industry 4.0 has driven digitization, smart industry solutions, IoT applications, and cyber-physical systems. As a result, the business landscape is evolving rapidly, product lifecycles are shortening, and consumer preferences are shifting, reflecting the ongoing digital transformation (Arends, 2021). Although progress has been made in education, the pace of technological disruption in the construction sectors of many countries has created disparities in the extent to which students are introduced to Construction 4.0. In particular, limited studies compare how polytechnics and universities deliver education that reflects different aspects of Construction 4.0. Table 1 presents a summary of recent literature on Construction 4.0 in education.

From Table 1, the reviewed literature indicates that limitations related to Construction 4.0 range from the scope of population studies to the breadth of dimensions being explored. This study is relevant as it examines how Construction 4.0 education is being delivered to students in polytechnic and university-built-environment programs.

Table 1: Current literature on construction 4.0 education

Authors	Focus	Methods	Limitation
Oke & Fernandes (2020)	The study examined the perceptions of key stakeholders in the education sector, particularly in Africa, regarding the readiness for and integration of the Fourth Industrial Revolution (4IR) into teaching and learning. The study investigates how prepared the sector is to adopt 4IR technologies, the perceptions of the potential disruptions and opportunities it presents, and how education systems can leverage 4IR to enhance teaching, research, and workforce readiness	Interview	The study focused on the level of readiness of African institutions to deliver academic training on 4IR technologies. It did not investigate the actual delivery of educational training on the subject matter.
Mian et al. (2020)	The central focus of the study was identifying the internal and external factors that influence the successful implementation of Industry 4.0 principles within higher education institutions. The research highlights the urgent need for universities to modernize their curricula, infrastructure, faculty expertise, and industrial partnerships to produce graduates skilled in artificial intelligence, data analytics, automation, and smart manufacturing.	Survey	The study's population was limited to university students only. Besides, Industry 4.0 encompasses a wide array of advanced technologies; the study could only include a subset of these technologies, potentially overlooking other relevant innovations or emerging trends.
Urban et al. (2022)	The study focused on augmented reality in Architecture Engineering and Construction education, emphasizing promoting students' productive use of AR.	Interview	The study was limited to investigating augmented reality out of the many components of Construction 4.0.
Soltani et al. (2023)	The study explored the adoption, challenges, enablers, and overall impact of Industry 4.0 (IR 4.0) technologies in the Australian construction industry. Specifically, it investigates the technological, social, cultural, and organizational factors influencing digital transformation in construction, including issues related to stakeholder engagement, diversity, gender equity, skills development, and regulatory considerations.	Survey	The study's limitation was that it centers on the practical application of the dimensions of Construction 4.0 and not on the training and education of students.
Ebekozien et al. (2024)	The study appraises professionals' perception of Education 4.0 and investigates the issues facing implementing Education 4.0 in Higher Education Institutions (HEIs).	Interview	The study's participants were limited to industry professionals.

2.2 Challenges in Adopting Construction 4.0 in Academia

In built environment education, Construction 4.0 is still not widely adopted. To address existing challenges in these programs, scholars have explored the potential of digital technologies in supporting educational outcomes. The adoption of digital tools can create an innovative learning environment that improves productivity, safety, quality, and sustainability in construction education (Wang et al., 2022). Interviews with built-environment faculty members have identified several barriers, including a lack of digital skills, unclear digital strategies, inconsistent industry standards, risk aversion, limited funding in early phases, outdated curricula, and insufficient resources. Other challenges include low access to technical support, weak peer collaboration, and a lack of expertise in using these technologies (Getin et al., 2023).

Integrating Construction 4.0, which encompasses digitalization, IoT, and Building Information Modeling (BIM), into academic processes presents complex challenges for educational institutions. These issues are made more difficult by the unpredictability that often characterizes the construction

sector (Olatunde et al., 2022). Previous studies have focused on specific obstacles, such as inadequate assessment methods, insufficient funding for acquiring or researching digital technologies, minimal inclusion of digital topics in accreditation frameworks, a shortage of qualified trainers, and limited industry partnerships that could provide needed support (Opoku et al., 2023).

2.3 Digital Skills Gap in the Built Environment

Research on Construction 4.0 still lacks a detailed evaluation of key foundational issues, such as limited stakeholder awareness of digital benefits, insufficient staffing for curriculum management, poor collaboration among academic departments, and the limited availability of software tools and platforms for digital technology integration (Heijden, 2023). Although many studies rely on academic assumptions, some of the documented challenges to student exposure in built-environment programs are supported by evidence. These obstacles are ranked based on how frequently they appear in the literature. Factors often overlooked include low digital expertise, minimal technology uptake, fragmented labor data, and doubts concerning the reliability of data quality. Several scholars have addressed these concerns recently (Lee et al., 2022).

2.4 Lessons from Global Best Practices

International studies have identified several effective practices in integrating Construction 4.0 into education. One key strategy involves hands-on practical training with Building Information Modeling (BIM) and Virtual Reality (VR) tools. These activities help students strengthen their technical knowledge, improve their understanding of construction workflows, and increase their employability in a technology-driven industry (Alizadehsalehi et al., 2021). Another approach involves the organization of industry-led workshops and seminars. These sessions give students access to current trends and technologies in Construction 4.0 while also allowing them to learn directly from professionals in the field. Through this exposure, students build awareness of real-world applications, gain practical insights, and improve their readiness for the evolving construction landscape (Newman et al., 2020; Lee & Lim, 2021).

Internships and cooperative education programs have also been highlighted as valuable methods for bridging the gap between classroom learning and professional experience. These opportunities help students apply theoretical concepts, build industry connections, and strengthen their problem-solving skills. Research suggests that such programs can significantly improve students' transition into employment and prepare them for long-term career success (Ogunode & Musa, 2020; Thakur et al., 2024; Yates et al., 2020).

Another effective measure is collaboration between academic institutions and construction companies. These partnerships allow students to participate in applied research and innovative projects that develop critical thinking and creativity. Working alongside industry professionals helps students better understand real-world challenges and contributes to academic-industry knowledge exchange (Supearno et al., 2023; Singh, 2024)

Finally, forming alliances with technology companies has been recognized as an important step. Students and educators gain access to advanced construction software and digital tools through these partnerships. This access allows educational institutions to incorporate cutting-edge technology into their curricula and stay aligned with industry standards. Research has shown that such collaborations provide training opportunities and resources essential for modern construction education (Riggio & Cheng, 2021; Wortman & Schiner, 2024).

3. METHODS

This study was conducted in a university and a polytechnic in Lagos, Nigeria. To validate the questionnaire, it was reviewed by the project supervisor to confirm that it satisfied essential statistical standards for research validity. A stratified and simple random sampling technique was

applied to select a representative sample of students. Due to structural and curricular differences between the two educational systems, stratified sampling was chosen to achieve proportionate representation from both institutions. This approach ensures that the findings related to students' exposure to Construction 4.0 reflect the diversity in Nigeria's higher education context. This area has not been extensively addressed in the literature (Ebekozien et al., 2024).

The study population consisted of final-year students from both university and polytechnic institutions. A sampling frame of 225 students was compiled, covering final-year students from programs including Architecture, Building, Estate Management, Quantity Surveying, Urban and Regional Planning, Surveying and Geoinformatics, Civil Engineering, Mechanical Engineering, and Electrical Engineering. The appropriate sample size for this study was calculated using Taro Yamane's formula, which is designed to determine a statistically valid sample size from a known population.

$$n = \frac{N}{1 + Ne^2} \qquad \text{Equation (1)}$$

where n = sample size, N = Population size, e = precision level

n=225/(1+225(0.05)^2 = 144 students

Copies of the structured questionnaire were distributed to 200 out of 225 students. A total of 154 completed questionnaires were retrieved and used for data analysis, yielding a response rate of 77 percent. The responses were coded and analyzed using the Statistical Package for the Social Sciences (SPSS, Version 23), and the R programming language was used to generate visualization plots. This study employed the Relative Importance Index (RII) to rank the factors that influence the learning exposure of built-environment students to Construction 4.0. The perceived importance of various factors affecting exposure was ranked separately for both institutional types using RII. Although RII is widely applied in construction research, its application for comparing institutional readiness in an educational context, particularly in developing countries, represents a relatively new direction (Peshkov, 2021). The formula used for the RII is presented as follows:

$$RII = \frac{\sum W}{\sum AN} \qquad \text{Equation (2)}$$

Where:

W = the weight given to each factor by the respondents, ranging from 1 to 5.

A = the highest weight = 5.

N = the total number of respondents.

4. RESULTS AND DISCUSSION

This section presents the findings of the study, organized into four subsections: respondent demographics, barriers to Construction 4.0 exposure, statistical comparisons between institutions, and a thematic discussion of the results. The analysis draws from quantitative data collected through structured questionnaires distributed to students enrolled in built-environment programs at a Nigerian university and polytechnic. Both descriptive and inferential statistical techniques were employed to identify key constraints affecting exposure to digital construction technologies and to determine whether significant differences exist between institutional contexts.

4.1. Respondents' Profile

Understanding the background of the respondents provides critical context for interpreting the results. Table 2 summarizes the demographic characteristics of the 154 students who participated in the survey, including gender, type of institution, academic department, and level of education.

Table 2 Demographic profile of respondents

Profile	N	Percent	Cumulative Percent
Gender			
Male	112	72.7	72.7
Female	42	27.3	100
Total	154	100	
Type of Institutions			
University	111	72.1	72.1
Polytechnic	43	27.9	100
Total	154	100	
Departments			
Architecture	11	7.1	7.1
Building	46	29.9	37
Quantity Surveying	19	12.3	49.4
Estate Management	21	13.6	63
Urban & Regional Planning	18	11.7	74.7
Surveying & Geoinformatics	6	3.9	78.6
Civil/Structural Engineering	10	6.5	85.1
Mechanical Engineering	8	5.2	90.3
Electrical Engineering	15	9.7	100
Total	154	100	
Level			
400	25	16.2	16.2
500	82	53.2	69.5
HND I	32	20.8	90.3
HND II	15	9.7	100
Total	154	100	

The gender distribution shows that 72.7% of the respondents were male, while 27.3% were female. This distribution reflects broader trends in gender representation within built-environment programs. Regarding institutional affiliation, 72.1% of respondents were from the university, and 27.9% were enrolled in the polytechnic. This distribution aligns with the sample design, which sought to capture insights from both academic pathways.

In terms of academic specialization, the respondents came from a diverse range of departments, including Building (29.9%), Estate Management (13.6%), Quantity Surveying (12.3%), Urban and Regional Planning (11.7%), and various engineering disciplines. This diversity enhances the representativeness of the data by incorporating perspectives from multiple areas within the built environment. Most respondents were in their final years of study: 53.2% were in 500-level courses, and 20.8% were in HND I, reflecting a student population with substantial academic exposure and familiarity with curriculum content.

4.2 Barriers Influencing the Learning Exposure of Built-Environment Students to Construction 4.0

Following the demographic overview, this subsection presents the key barriers that affect students' engagement with Construction 4.0 content and practices. Drawing on responses from both university and polytechnic students, the data highlight the challenges encountered in curriculum delivery, resource availability, institutional coordination, and student readiness. Table 3 presents a ranked list of 24 identified barriers, analyzed using the Relative Importance Index (RII) to assess the severity of each factor from the perspectives of students at both institution types.

Table 3 Factors Influencing Learning Exposure of Built-Environment Students to Construction 4.0

Barriers	N		RII		Rank	
	U	P	U	P	U	P
Outdated curriculum that does not include digital technologies	111	43	0.79	0.83	1	4
Limited availability of qualified personnel to train faculty and students on digital technologies	111	43	0.79	0.78	2	11
Insufficient funding for research on digital technologies and their applications in built-environment programs	111	43	0.79	0.83	3	3
Insufficient infrastructure includes poor internet connectivity, unreliable power supply, and inadequate computer labs or equipment.	111	43	0.79	0.86	4	1
Lack of funding and resources to procure necessary digital technologies	111	43	0.78	0.84	5	2
Limited access to technical support for faculty and students	111	43	0.77	0.78	6	10
Limited availability of training and workshops for students to develop their digital technology skills	111	43	0.76	0.78	7	15
Lack of collaboration between academic departments in integrating digital technologies	111	43	0.76	0.79	8	7
Inadequate assessment methods for evaluating the effectiveness of digital technologies	111	43	0.76	0.77	9	14
Insufficient emphasis on digital technologies in the accreditation process	111	43	0.76	0.81	10	5
Limited support for open-source software and free tools that are accessible to students and faculty members	111	43	0.75	0.71	11	22
Lack of industry partnerships to provide the necessary support for digital technologies	111	43	0.75	0.81	12	6
Low awareness or knowledge of the benefits of digital technologies by stakeholders	111	43	0.74	0.73	13	20
Limited funding for student-led projects that require digital technologies	111	43	0.74	0.75	14	17
Students' Attitude towards Use	111	43	0.74	0.78	15	9
Insufficient availability of software, tools, and applications to support the integration of digital technologies	111	43	0.74	0.78	16	8
Inadequate staffing levels to manage the use of digital technologies in the curriculum	111	43	0.74	0.77	17	13
Student Intentions to Use	111	43	0.73	0.78	18	12
Uncertainties with data quality and reliability	111	43	0.72	0.68	19	24
Difficulties in data storage, processing, and analysis	111	43	0.71	0.73	20	19
Resistance to change by faculty and staff members.	111	43	0.71	0.76	21	16
Inadequate security measures to protect digital data and intellectual property rights	111	43	0.70	0.73	22	18
Fragmented composition of workforce data	111	43	0.68	0.69	23	23
Lack of peer support from students	111	43	0.64	0.71	24	21

Note: N is the number of Respondents; RII is the Relative Importance Index; U is University, and P is Polytechnic.

The findings show that insufficient infrastructure, including unreliable internet connectivity and inadequate computer laboratories, received the highest RII score (0.81), followed by outdated

curricula and limited funding resources. These top-ranked barriers point to critical structural limitations that prevent effective integration of Construction 4.0 in tertiary education settings. Outdated course content, in particular, was cited as a direct impediment to learning digital construction tools, which students felt placed them at a disadvantage in the labor market.

Additional challenges included the lack of access to qualified trainers, minimal industry partnerships, and insufficient digital tools. Students also reported inadequate opportunities for practical application, such as workshops or software training. From an educational standpoint, these constraints reduced the scope for experiential learning and project-based instruction, both of which are essential for developing Construction 4.0 competencies. Economically, the absence of investment in digital education infrastructure has limited students' ability to contribute to innovation or meet employer expectations in a rapidly digitizing industry.

Furthermore, students expressed concern over the misalignment between accreditation processes and technological expectations. Several barriers ranked in the mid-tier, such as limited peer support, student attitudes toward digital tools, and restricted access to technical assistance, reflect individual-level and institutional culture issues that must be addressed to build a digitally competent workforce. The next subsection will present the results of statistical tests used to compare students' perceptions of universities and polytechnics.

4.3 Test of Hypothesis

To determine whether differences exist in how university and polytechnic students perceive barriers to Construction 4.0 exposure, a Mann-Whitney U test was conducted. The test evaluated the null hypothesis that there is no statistically significant difference between the perceptions of the two groups regarding the identified barriers. Table 4 presents the statistical output, showing each barrier alongside its corresponding mean rank scores, U-values, and p-values for both institution types.

The results demonstrate that, for 23 out of 24 barriers, there was no statistically significant difference between university and polytechnic students' responses. This suggests a shared experience of the challenges of accessing Construction 4.0 content, indicating systemic issues across institutional contexts. However, the barrier related to "lack of peer support from students" yielded a p-value of 0.040, below the 0.05 threshold, indicating a statistically significant difference. Polytechnic students reported lower levels of peer support, suggesting that these institutions may have weaker support structures or less collaborative learning environments.

Table 4: Mann-Whitney U Test Results

Barriers	U_1		P_1		U	*P*-Value	Remark
	N	MS	N	MS			
Resistance to change by faculty and staff members.	111	74.70	43	84.72	2076.000	.195	NS
Lack of peer support from students	111	73.09	43	88.87	1897.500	.040	S
Student Intentions to Use	111	75.13	43	83.63	2123.000	.271	NS
Students' Attitude towards Use	111	75.83	43	81.80	2201.500	.438	NS
Fragmented composition of workforce data	111	76.80	43	79.31	2308.500	.742	NS
Outdated curriculum that does not include digital technologies	111	76.21	43	80.83	2243.500	.535	NS
Insufficient infrastructure includes poor internet connectivity, unreliable power supply, and inadequate computer labs or equipment.	111	74.71	43	84.71	2076.500	.179	NS
Inadequate assessment methods for evaluating the effectiveness of digital technologies	111	74.50	43	85.24	2053.500	.160	NS
Lack of funding and resources to procure necessary digital technologies	111	75.10	43	83.69	2120.500	.253	NS
Insufficient funding for research on digital technologies and their applications in built-environment programs	111	76.07	43	81.19	2228.000	.498	NS

Barriers	U_1		P_1		U	*P*-Value	Remark
	N	MS	N	MS			
Insufficient emphasis on digital technologies in the accreditation process	111	75.14	43	83.60	2124.000	.269	NS
Limited availability of qualified personnel to train faculty and students on digital technologies	111	78.86	43	73.98	2235.000	.520	NS
Lack of industry partnerships to provide the necessary support for digital technologies	111	74.19	43	86.03	2019.500	.123	NS
Limited access to technical support for faculty and students	111	77.35	43	77.88	2370.000	.945	NS
Low awareness or knowledge of the benefits of digital technologies by stakeholders	111	78.36	43	75.27	2290.500	.689	NS
Inadequate staffing levels to manage the use of digital technologies in the curriculum	111	75.60	43	82.40	2176.000	.378	NS
Lack of collaboration between academic departments in integrating digital technologies	111	76.36	43	80.43	2260.500	.596	NS
Insufficient availability of software, tools, and applications to support the integration of digital technologies	111	75.36	43	83.01	2149.500	.321	NS
Limited availability of training and workshops for students to develop their digital technology skills	111	76.88	43	79.16	2315.000	.764	NS
Limited support for open-source software and free tools that are accessible to students and faculty members	111	79.61	43	72.05	2152.000	.326	NS
Limited funding for student-led projects that require digital technologies	111	76.91	43	79.03	2320.500	.782	NS
Inadequate security measures to protect digital data and intellectual property rights	111	75.83	43	81.81	2201.000	.440	NS
Uncertainties with data quality and reliability	111	79.24	43	73.00	2193.000	.418	NS
Difficulties in data storage, processing, and analysis	111	76.59	43	79.85	2285.500	.672	NS

Note: *p* is significant at p≤0.05, and MS=Mean Score, U is Mann-Whitney, U1 is the university, P_1 is Polytechnic, S= Significant, NS=not significant.

This finding is further visualized in Figure 1, which displays the distribution of student perceptions across both institution types. The boxplot illustrates that, although the distributions are largely similar, certain barriers have a slightly greater perceived impact on polytechnic students.

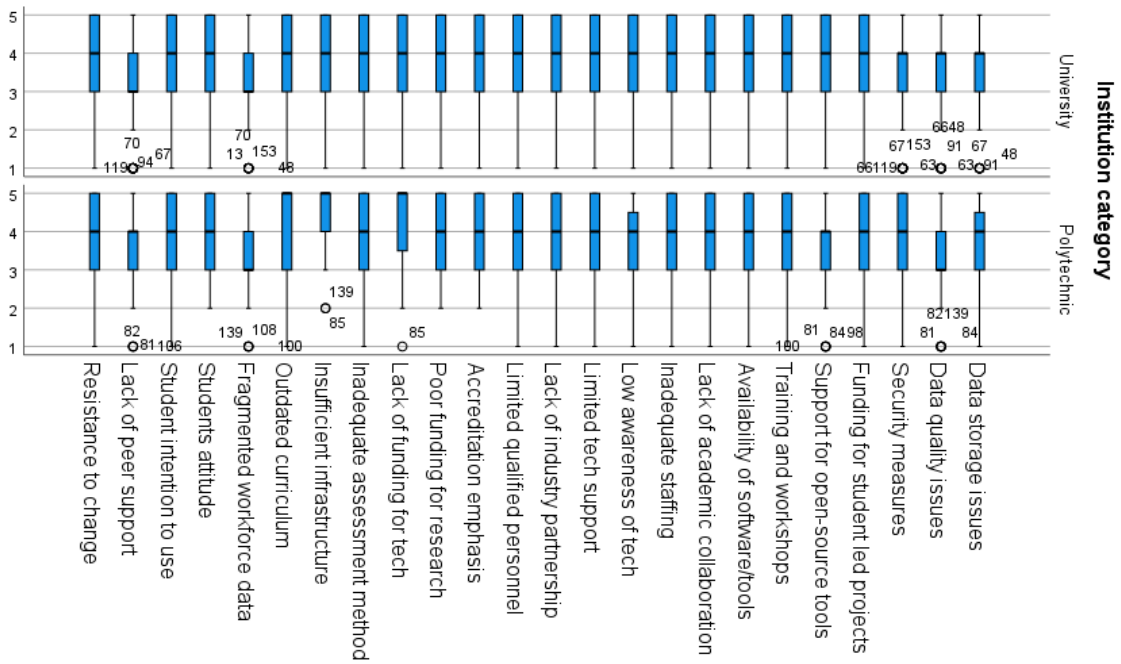

Figure 1 Visualization of the perception of university and polytechnic students regarding the barriers to learning exposure of students to Construction 4.0

A Wilcoxon rank-sum test was also performed using R programming to corroborate the Mann-Whitney results. The computed test statistic (W = 380) yielded a p-value of 0.06, which supports the conclusion that most barriers are similar across both institutions, with only minor differences. Additionally, R programming was used to conduct further analysis and visualize the perceptions of university and polytechnic students regarding these barriers through the Wilcoxon test of difference. The study produced a Wilcoxon value (W) of 380; the corresponding visualization is shown in Figure 2.

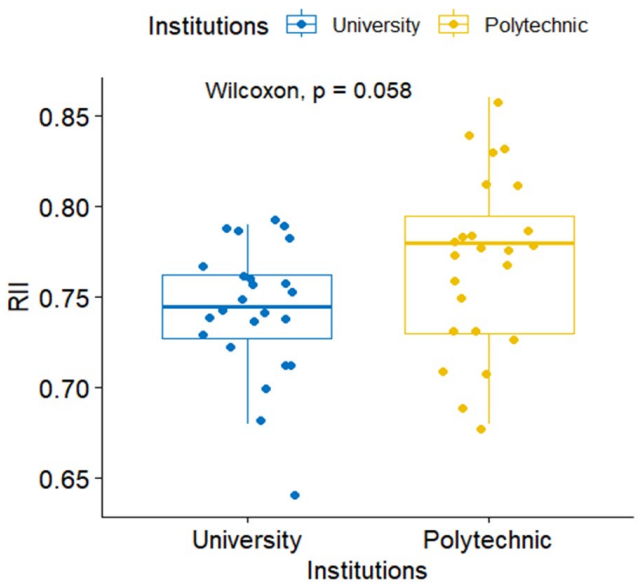

Figure 2 Visualization of university and polytechnic Students' Perception of the Barriers to Construction 4.0 Learning Exposure

These findings emphasize that, while the institutional type is limited in shaping perceptions of most barriers, polytechnic students may require additional peer collaboration mechanisms to improve their exposure to digital learning tools.

4.3 Discussion of Findings

The findings reveal several prominent barriers perceived by university and polytechnic students. These include resistance to change among faculty and staff, outdated curricula, inadequate assessment methods, and limited emphasis on digital technologies within accreditation systems. These barriers largely stem from institutional reliance on traditional approaches and a slow transition toward integrating digital technologies such as Building Information Modeling (BIM), Augmented Reality (AR), and automation. Many faculty members lack the necessary skills to prepare students for recent technological developments. Without policy-based reform at the institutional level, these obstacles are likely to persist and continue limiting students' exposure to Construction 4.0.

The results of this study are consistent with the work of Mannan et al. (2023), which identified insufficient infrastructure, outdated curriculum, limited funding, and a shortage of qualified personnel as key factors affecting students' exposure to Construction 4.0.

Inadequate infrastructure and lack of funding for digital technologies underscore limited government investment in digital transformation within polytechnics and universities, particularly in developing regions. These institutions frequently experience internet disruptions, unreliable power supply, and under-resourced computer laboratories, all hindering effective learning (Vicente et al., 2020). The high cost of licensed digital tools prevents institutions from incorporating BIM software, AI-based simulations, and digital twin technology into built-environment education (Jahangir et al., 2024). To address these issues, government funding is needed to support digital education, upgrade infrastructure, and facilitate the acquisition of essential digital tools.

Construction 4.0 processes require students to develop both knowledge and practical skills (Newman et al., 2020). The limited resources and infrastructure currently available restrict student access to comprehensive training. Institutions with more resources and stronger links to industry were more successful in providing students with Construction 4.0 exposure (Hu et al., 2022).

Among the twenty-four identified barriers, only "lack of peer support from students" was statistically significant, suggesting that polytechnic students experience more difficulty in this area than their university counterparts. The remaining twenty-three barriers were not statistically significant, which indicates that both institution types encounter similar challenges in most aspects. This finding supports the observation by Ebekozien (2022), who reported that issues such as inadequate infrastructure, outdated curricula, and limited availability of qualified personnel are major obstacles to student exposure to Construction 4.0 in built-environment programs in Nigeria.

Results from the Mann-Whitney U test further highlight this distinction. While most barriers were perceived similarly by students from both institutions, peer support emerged as a statistically significant point of difference. This suggests that polytechnic students may feel more isolated, with fewer opportunities for collaboration in digital technology learning environments. In contrast, university students may benefit from stronger academic networks, mentorship initiatives, or peer-led programs that promote the development of digital competencies.

5. CONCLUSION

Based on the findings, this study concludes that several interconnected barriers hinder students' learning exposure to Construction 4.0. These include fragmented workforce data, limited funding for digital technologies, inadequate research support, poor infrastructure, and a shortage of qualified personnel. These obstacles reflect broader institutional challenges involving policy frameworks, faculty readiness, resource constraints, collaboration with industry, student engagement, and social expectations.

The study recommends universities and polytechnics revise curricula to incorporate construction 4.0 technologies such as building information modeling (BIM), artificial intelligence (AI), and automation. Students in Nigerian tertiary institutions should have greater access to these technologies. Institutions are encouraged to implement structured digital training programs for lecturers so they are well-prepared to teach using modern technological tools. Government investment in high-speed internet and reliable power supply is critical to support this transition. In addition, private sector involvement can strengthen institutional capacity by establishing technology laboratories, offering access to specialized software, and supporting student-led research initiatives.

The barriers identified in this study require broad institutional changes. Addressing them will demand improvements in infrastructure, curriculum development, faculty competence, and student peer support systems, particularly within polytechnic settings.

To improve student exposure to digital technologies, it is important to integrate internships and industry-based projects into academic programs. Educational institutions should pursue strong partnerships with industry stakeholders to create these opportunities and offer students real-world experience applying Construction 4.0 concepts.

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A MODEL OF TRIPS ROUTE PLANNING TO IMPROVE THE ACCESSIBILITY OF PUBLIC TRANSPORTATION IN BENGKALIS CITY USING GEOGRAPHIC INFORMATION SYSTEM (GIS)

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ABSTRACT

The increase in population and motorized vehicles in Bengkalis City has led to greater demand for public transportation, which remains insufficient in meeting accessibility needs. This study aims to develop a model for planning public transportation routes using Geographic Information System (GIS) tools to improve accessibility in Bengkalis City. The study employs primary data from field surveys and secondary data from relevant agencies. GIS-based spatial analysis methods, such as service area analysis and the Origin-Destination (OD) matrix, are applied to evaluate accessibility and passenger movement patterns. The analysis results in two route alternatives assessed based on stop point density, community accessibility, and passenger distribution. The first alternative is identified as more effective in serving population centers and minimizing service gaps. The findings provide a spatially grounded approach to transportation planning and may support local efforts to improve public transport coverage.

Keywords: ArcGIS; Origin Destinantion (OD); Route

1. INTRODUCTION

Bengkalis City, also known as "The Terubuk City," in Riau Province, has experienced rapid development. This is reflected in the population growth rate between 2020 and 2023, which reached 1.43%, bringing the total population to 86,198 (Kabupaten Bengkalis Dalam Angka, 2024). Alongside this growth and rising economic activity, the demand for efficient and accessible transportation infrastructure has become increasingly urgent. However, Bengkalis City faces several transportation-related challenges, including limited infrastructure and inadequate access to peripheral areas.

The city consists of widely dispersed villages, with the city center as the hub for economic and governmental activities. Transportation accessibility is key in supporting community mobility and driving economic development. For this reason, identifying innovative and practical strategies to improve the affordability and reach of transportation in Bengkalis City remains a key objective.

To support mobility and daily activities, transportation facilities, particularly public transport—must be sufficient and reliable. The public transport system has a direct impact on the broader transportation network. A poorly managed system can disrupt urban functions, making it difficult to meet mobility needs and affecting the overall quality of urban life.

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Geographic Information Systems (GIS) provide a practical approach to addressing transportation challenges. With tools like ArcGIS, planners can make informed decisions based on accurate geo

graphic data. This technology supports a detailed analysis of transportation networks, patterns of population movement, and other factors that influence urban mobility.

This study aims to develop a trip route planning model using GIS to improve public transport accessibility in Bengkalis City. In addition, alternative route planning is required to reach destinations based on passenger demand and factors such as road geometry. According to Idwan Susanto (in Buchika et al., 2018), a well-designed route provides optimal service to passengers within its area by making the best use of available resources.

2. LITERATURE STUDY

2.1. Transportation

Transportation can be defined as moving, mobilizing, carrying, or transferring an object from one location to another, where it becomes more useful or can serve a specific purpose (Miro, 2005). Transportation is also considered a derived demand, as people travel not solely for personal reasons but also for work, shopping, education, and more (Khisty & Lall, 2003). Thus, the criteria for determining transportation service needs involve two aspects: the users of the transportation services and the transportation system itself (Miro, 1997). Transportation development connects supply sources, production sites, marketing areas, and residential zones. The concept of transportation is built upon the movement between origins and destinations. It may also be described as a system comprising infrastructure and services that facilitate people's movement across areas.

2.2. Relation between Land Use and Transportation Planning

Transportation systems encompass various activities, including industry, tourism, commerce, agriculture, mining, and others. These activities occur on land—industries, rice fields, mines, and urban areas—all commonly called land use. People use transportation networks to travel between land uses to fulfill their needs. This results in the movement of people, vehicles, and goods (Tamin, 2000) and generates interactions between urban markets and industrial zones, urban and agricultural areas, tourism sites, and factories and supply or market locations.

Urban land is classified into two categories: built-up and non-built-up areas. Built-up land is used for housing, industry, services, trade, and offices. In contrast, non-built-up land includes recreational areas, plantations, waterways, and agricultural land, functioning as natural resources and open space. According to Hartshorne (in Hubert & S, 2006), land use can be categorized into private and public uses. Private uses include residential, commercial, and industrial purposes, while public uses include recreational and educational facilities.

The main goal of transportation planning is to facilitate interactions simply and efficiently. The spatial distribution of land uses (activity system) and the availability or placement of transportation infrastructure (network system) are integrated to estimate traffic volumes and patterns (movement system). These traffic patterns influence the development of new land uses and infrastructure (Tamin, 2000). Each traveler has a distinct purpose, and these differences affect the routing of public transportation services, as travel needs vary by individual.

2.3. Four Step Models

According to Tamin (2000), The Four Step Model (FSM) is a widely used framework in transportation planning composed of four sequential stages. The first stage, Trip Generation, involves estimating how often individuals travel by analyzing trip ends, which include trip productions and attractions. These elements are assessed separately to understand trip frequency and

spatial origins. The second stage, Trip Distribution, links the trip productions with trip attractions by accounting for travel impedance such as time and cost. This results in a trip table that reflects the volume of person-trip demand between zones. The third stage, Mode Choice, adjusts the trip table to represent how travelers choose among available transportation modes, such as private vehicles, public transit, or walking. Finally, in the Trip Assignment stage, trips are allocated to specific routes within the transportation network according to the selected mode. This step often incorporates time-based variables—such as the time of day—to better replicate travel patterns. These four stages form an integrated system for predicting and managing urban transportation flows.

2.4. Public Transport

Public transportation plays a crucial role in urban transportation systems, serving as a key indicator of a city's level of development (Hartono, 1994). A well-functioning public transport network helps facilitate mobility by collecting and distributing individuals who need to travel across different parts of the city. It reduces traffic congestion, improves access to services, and supports economic activities.

According to Vuchic (1981), public transportation modes can be categorized based on operation and usage into two main types. The first is paratransit or charter transportation, which includes services operators provide for private hire, such as taxis and chartered buses. The second is urban or mass transit, which consists of services that operate on fixed schedules and routes and are accessible to the general public for a fee. These two classifications reflect public transportation systems' diversity and ability to meet varying travel needs within urban areas.

2.5. Public Transportation Route Determination

Public transportation routes are typically determined by the mode of transport being used. Modes such as buses and trains usually operate on fixed routes, requiring route and mode selection to occur simultaneously. This differs from private vehicle use, where individuals generally choose their mode first and then decide on a preferred route. The nature of public transportation, with its structured schedules and defined pathways, necessitates careful planning to meet travel demand efficiently.

According to Tamin (2000), several factors influence a traveler's route selection. These include travel time, which refers to the total duration of the journey; travel costs, covering expenses such as fuel, tolls, and service fees; and time value, which reflects how much a traveler prioritizes minimizing travel duration. Additionally, vehicle operating costs, such as fuel consumption and maintenance, impact route decisions. These factors collectively guide planners and users in identifying the most suitable routes within an urban transportation network.

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2.6. Route Service Area Determination

A public transportation route's service area is defined as the region where residents can access the route's services. It includes locations within a convenient walking distance, allowing passengers to use transit services to reach their destinations. The standard corridor width for a service area is approximately 800 meters, encompassing 400 meters to the left and right of the route (LPKM-ITB, 1997).

2.7. Origin-Destinantion (OD)

The origin-destination (OD) matrix is a two-dimensional table that captures the movement volume between different zones within a given area. Rows represent origin zones, and columns represent destination zones; each cell contains the movement volume between a pair of zones.

2.8. Bus Stop

According to Vuchic (1981), bus stop locations can be classified into three categories based on their placement relative to intersections. Near Side (NS) stops are positioned before an intersection, Far Side (FS) stops are placed just after passing through an intersection, and Midblock (MB) stops are located between intersections. These categories help organize bus stop placement to improve traffic flow and enhance passenger convenience.

Bus stops are generally installed in areas with high demand for public transportation and are planned with surrounding traffic conditions in mind (Ogden & Bennet, 1984). When placing stops near intersections, additional factors must be considered. For example, putting a stop before the intersection is advisable when there is heavy right-turning traffic, while a far-side stop is preferable if left-turning traffic is more frequent. In intersections that serve multiple public transport routes, planners must also consider passenger walking distances and minimize potential conflicts between pedestrians and vehicles to support safe and efficient transfers.

3. METHODS

3.1. Study Area

This research was conducted in Bengkalis City, Riau Province, by dividing the study area into several zones (see Figure 1). The research focuses on eight villages within the Bengkalis sub-district, which contains various activity centers such as residential areas, educational institutions, government offices, and commercial zones.

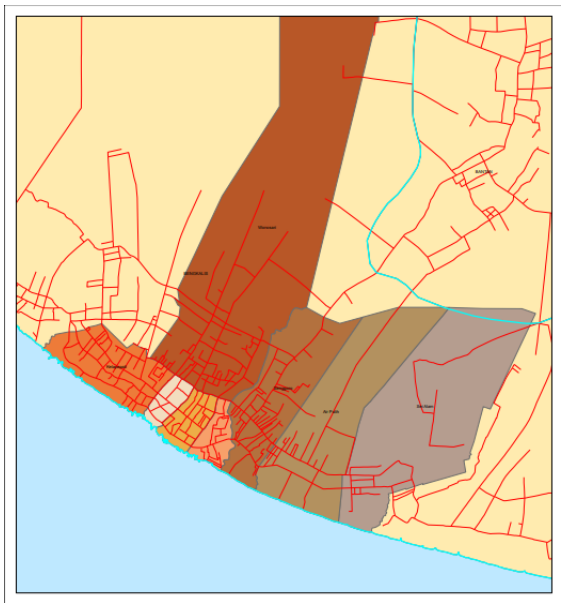


Figure 1 Study Area

3.2. Processing Methodology

Several steps were carried out during this research, as outlined below.

3.2.1. Preparation Stage

At this stage, the research began with planning activities, including identifying the problem and determining the research objectives. In addition, a literature study was conducted to develop a deeper understanding of the data demand that would be addressed in the processing stage. Literature sources were obtained from journals, articles, theses, research reports, and other relevant reading materials.

3.2.2. Data Collection Stage

The data collection method used in this study is the Slovin sampling method. This method is commonly applied in research to determine the minimum number of samples required from a large population. The formula used for the calculation is as follows:

The study population consisted of final-year students from both university and polytechnic institutions. A sampling frame of 225 students was compiled, covering final-year students from programs including Architecture, Building, Estate Management, Quantity Surveying, Urban and Regional Planning, Surveying and Geoinformatics, Civil Engineering, Mechanical Engineering, and Electrical Engineering. The appropriate sample size for this study was calculated using Taro Yamane's formula, which is designed to determine a statistically valid sample size from a known population.

$$n = \frac{N}{1 + Ne^2} \qquad \text{Equation (1)}$$

where n = number of samples, N = total population, e = tolerated margin of error (maximum e=10%)

In addition, interview data from the residents in the selected zones are used as primary data. These interviews are conducted conventionally through home visits. A home interview refers to conducting interviews by visiting households individually (door to door) to obtain a sample of household respondents. The collected interview data are used to determine demand values in the origin-destination matrix for each area.

This study makes use of both primary and secondary data sources. Primary data is gathered through direct interviews conducted with residents in selected areas, providing insights into trip demand and travel behavior. Meanwhile, secondary data consists of existing records and documents obtained from relevant government institutions and agencies, offering essential contextual and spatial information to support the analysis.

One major source of secondary data is the Regional Development Planning Board (BAPPEDA) of Bengkalis District. From this institution, the study incorporates several key datasets, including the Regional Spatial Plan (RTRW) of Bengkalis Regency 2022–2024, the Land Use Map of Bengkalis Regency, and the Village Administration Boundary Map of Bengkalis District. These materials help define the geographical scope of the study and provide a spatial framework for route planning.

Additional secondary data is obtained from the Central Statistics Agency (BPS) of Bengkalis Regency, particularly population data for Bengkalis City, which is essential for calculating demand and applying expansion factors. Furthermore, the Public Works Department of Bengkalis Regency contributes important infrastructure information, such as the Road Network Map and the Spatial Pattern Map of Bengkalis City, which are used in the development and validation of proposed public transportation routes.

3.2.3. Data Processing Stage

In stage, interview data are compiled and processed using Microsoft Excel to produce demand values for the origin-destination matrix. By analyzing the distribution of origin-destination flows, zones with the highest potential travel demand can be identified. This analysis serves as a supporting factor in selecting appropriate travel routes. Travel routes are developed through digital mapping with the support of ArcGIS software.

Mapping demand using ArcGIS

ArcGIS is used to input the demand values into the study area map. Each value is assigned a color gradient to identify zones with the highest travel demand. A darker color indicates a higher demand level. The visualization of this process is shown in Figure 2.

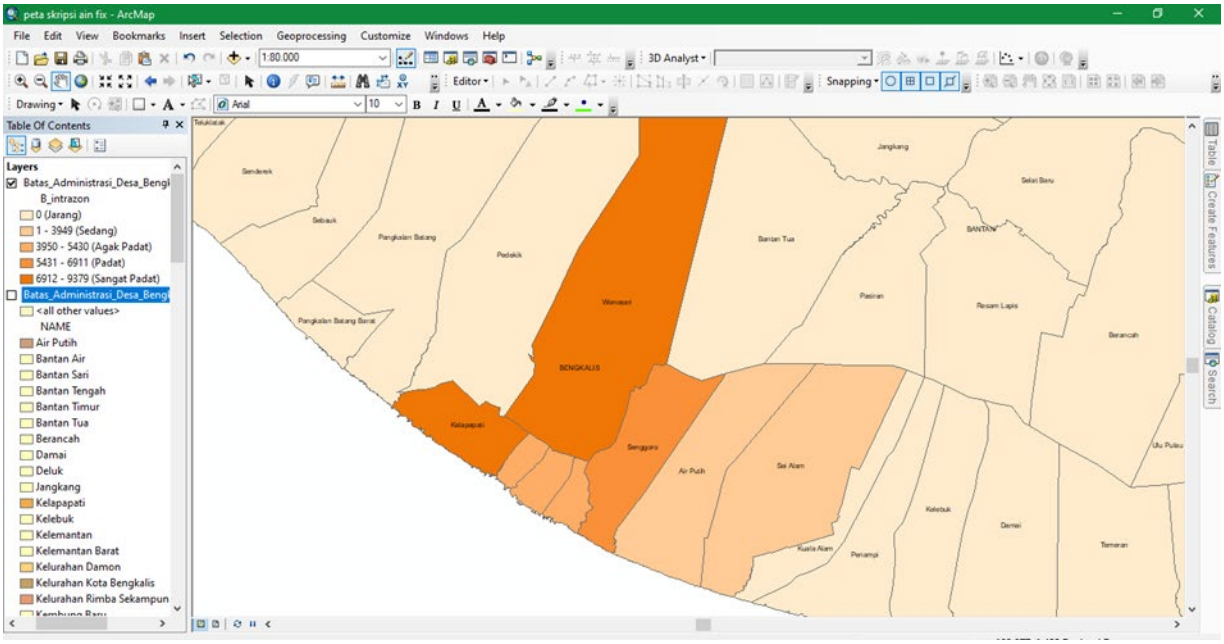
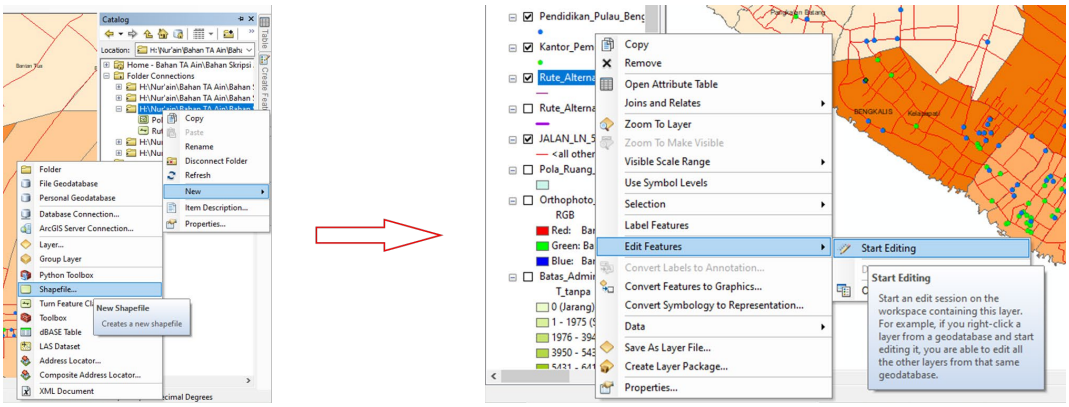


Figure 2 Map Showing Demand in the Study Area

Identify feasible zones and create the route

An analysis is conducted to determine which areas are suitable for inclusion in the planned travel route. In addition to demand figures, the selection is based on spatial characteristics such as the presence of government offices, educational institutions, shopping centers, and residential areas. After the analysis, a route is drawn using ArcGIS. The steps for creating and editing the shapefile can be seen in Figures 3(a) and 3(b), while the resulting route is illustrated in Figure 4.



(a) (b)

Figure 3 How to Make a New Shapefile (a), Start Editing (b)

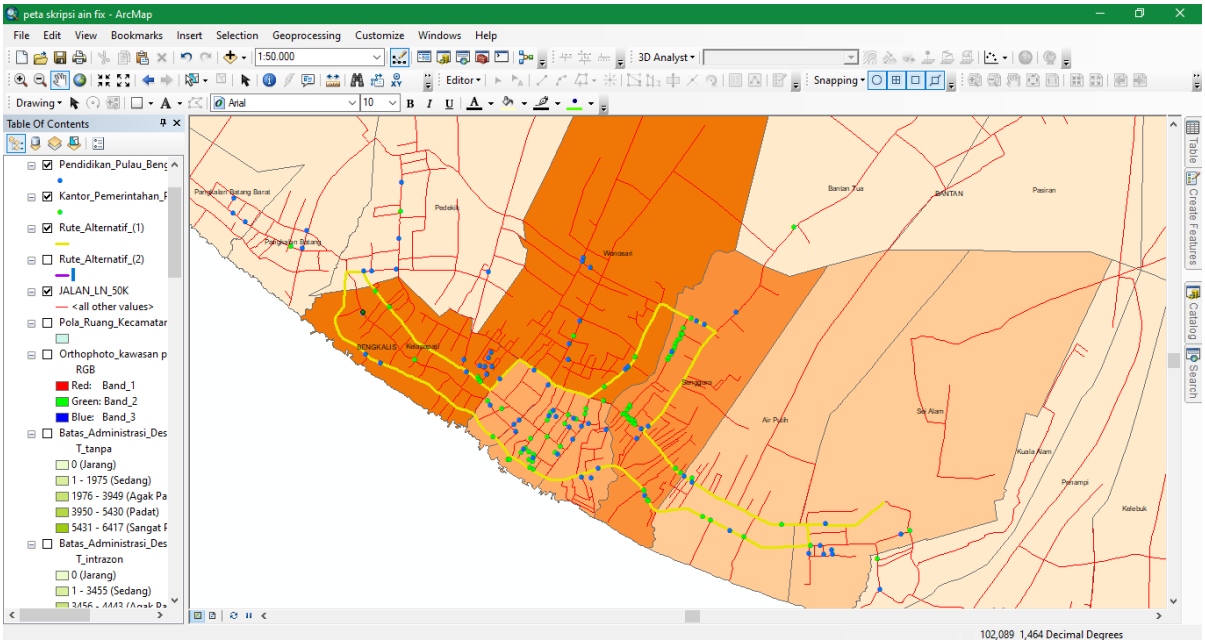


Figure 4 Alternative Route 1

Placing Bus Stops Along the Route

Once the travel route is created, bus stop points are placed along the path. Google Earth is used to identify and put the bus stop locations. These points are then converted into a shapefile format using Global Mapper and imported into ArcGIS, where the bus stops are displayed on the designated route. The placement process is shown in Figure 5, the file conversion is shown in Figure 6, and the final result is shown in Figure 7.

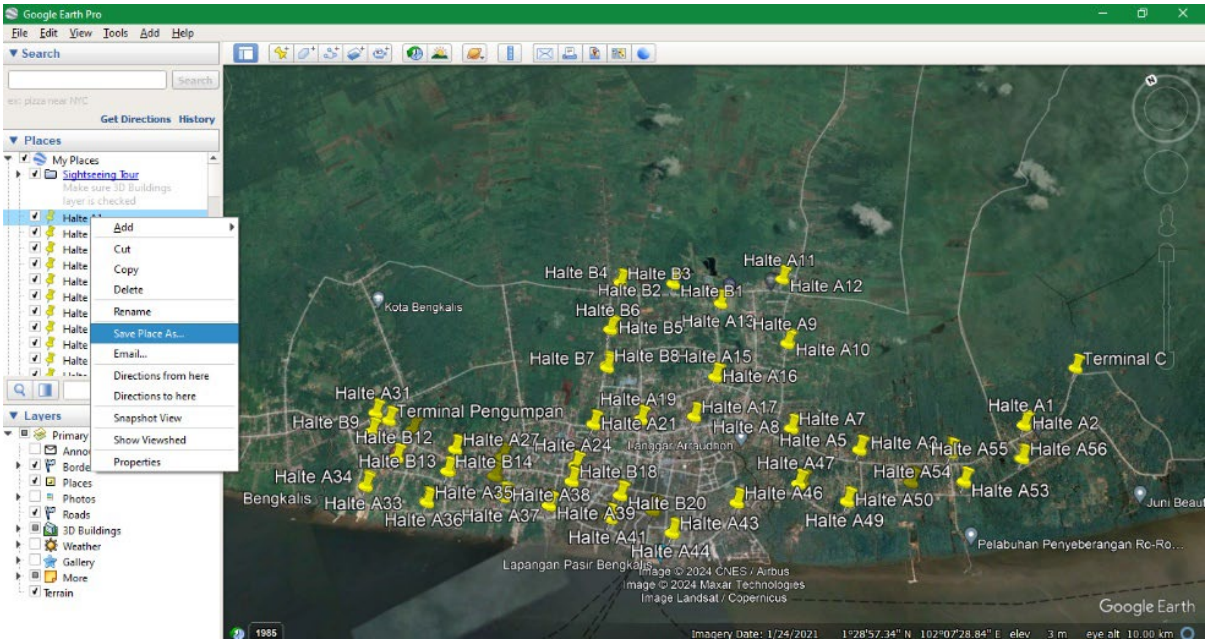


Figure 5 The Placement of Bus Stops Using Google Earth

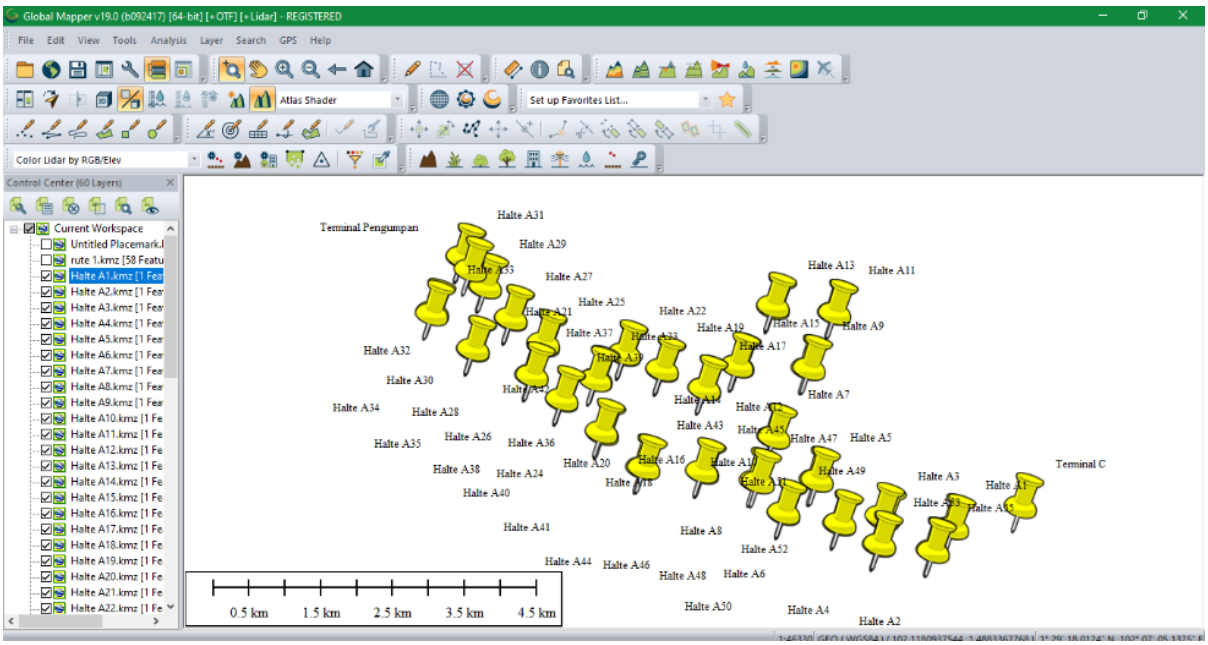


Figure 6 Convert into Shapefile Using Global Mapper

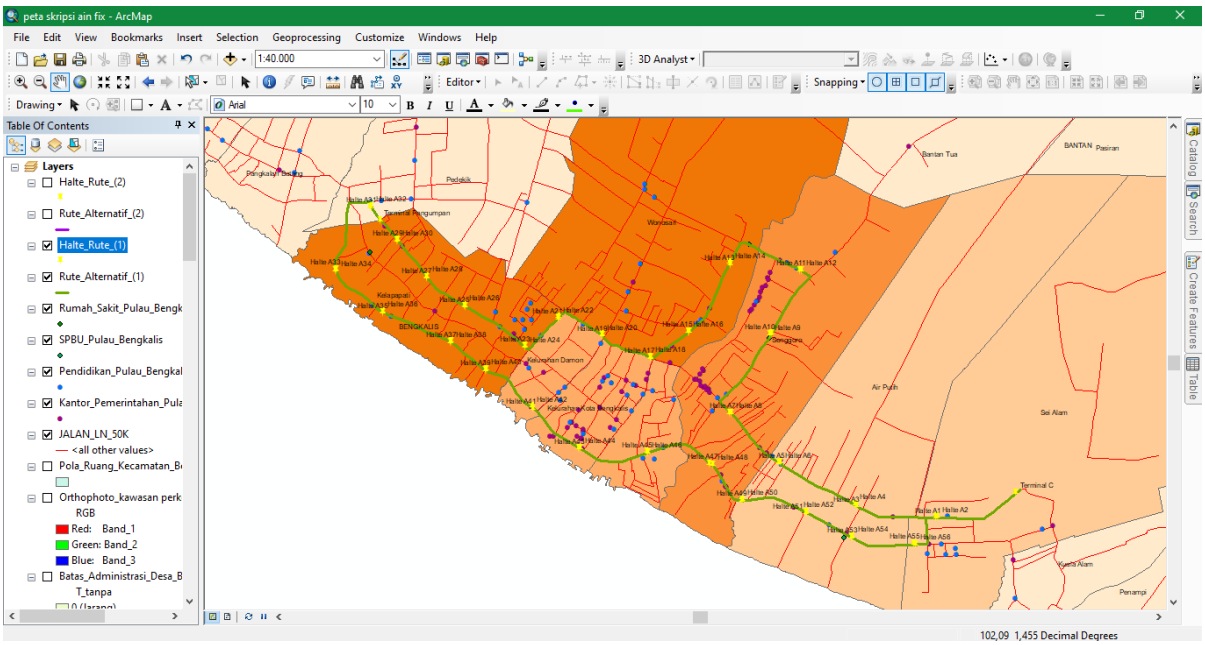


Figure 7 Route and Bus Stops

Route Comparison and Selection

After designing Alternative Route 1 and Alternative Route 2, the final step is to compare both options and determine the most suitable route for implementation. The decision is made based on factors such as coverage, connectivity to demand centers, and alignment with spatial development patterns.

4. RESULTS AND DISCUSSION

4.1. Respondents' Profile

According to Bengkalis Regency in Numbers of 2024, the total population of Bengkalis Sub-district in 2023 is 86,198. This population figure is then used in the Slovin formula to calculate the minimum required sample size, as shown below.

$$n = \frac{86198}{1+86198 \cdot 0.1^2}, n = 99{,}98 \neq 100 \text{ people}$$

Applying a margin of error of 10%, the calculation resulted in a sample size of 100 respondents. Sampling was conducted using a random sampling method across eight villages in Bengkalis District. These villages are listed in Table 1 below.

Table 2 Sample respondents sub-district Bengkalis

Zone	Vilages	Population	Percentage of Population per Zone	Sample
1	Sungai Alam	2866	5,81%	6
2	Air Putih	4161	8,43%	8
3	Senggoro	7607	15,41%	16
4	Rimba Sekampung	5399	10,94%	11
5	Bengkalis Kota	5835	11,82%	12
6	Damon	5381	10,90%	11
7	Kelapapati	8567	17,35%	17
8	Wonosari	9548	19,34%	19
	TOTAL	**49364**	**100%**	**100**

4.2. Characteristics of Study Area Respondents

The survey was conducted throughout the entire study area to identify the percentage of trip demand in each village. The results describing respondent characteristics are presented below as a representative sample.

4.2.1. Characteristics Based on Age

Based on the respondents' age distribution, the most dominant group falls within the 17–25 age range, accounting for 36% of the sample. This is followed by respondents aged over 40 years at 35% and those in the 26–40 age range at 29%. The age-based characteristics of respondents are illustrated in Figure 8.

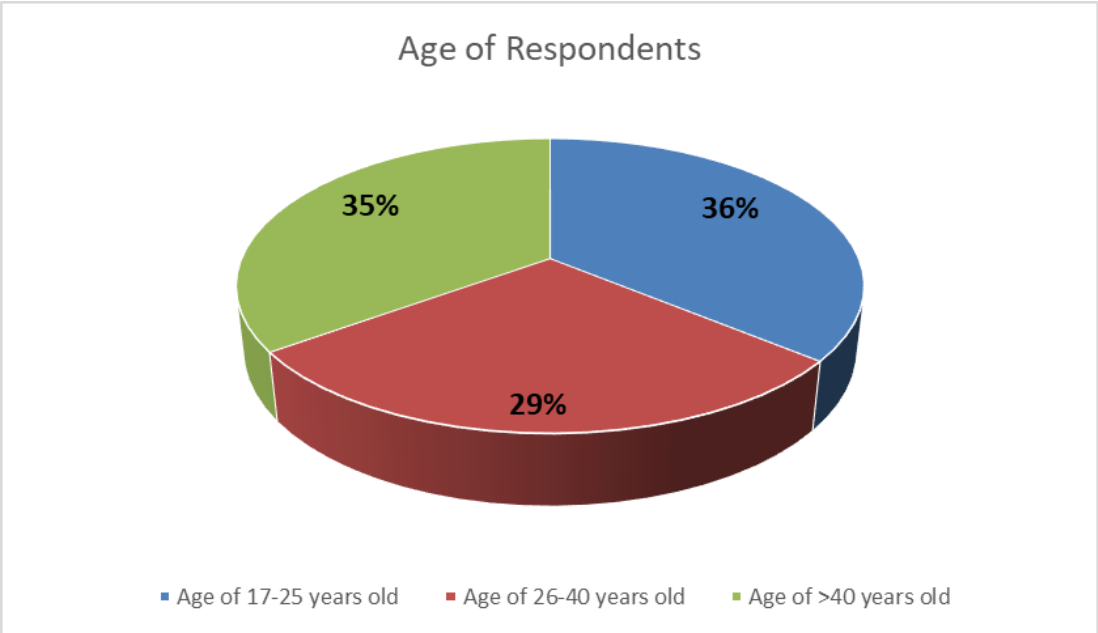


Figure 8 Characteristics of Respondents based on Age

4.2.2. Characteristics Based on Gender

The classification of respondents by gender shows that males represent the dominant group at 53%, while females account for 47%. The gender distribution of respondents is illustrated in Figure 9.

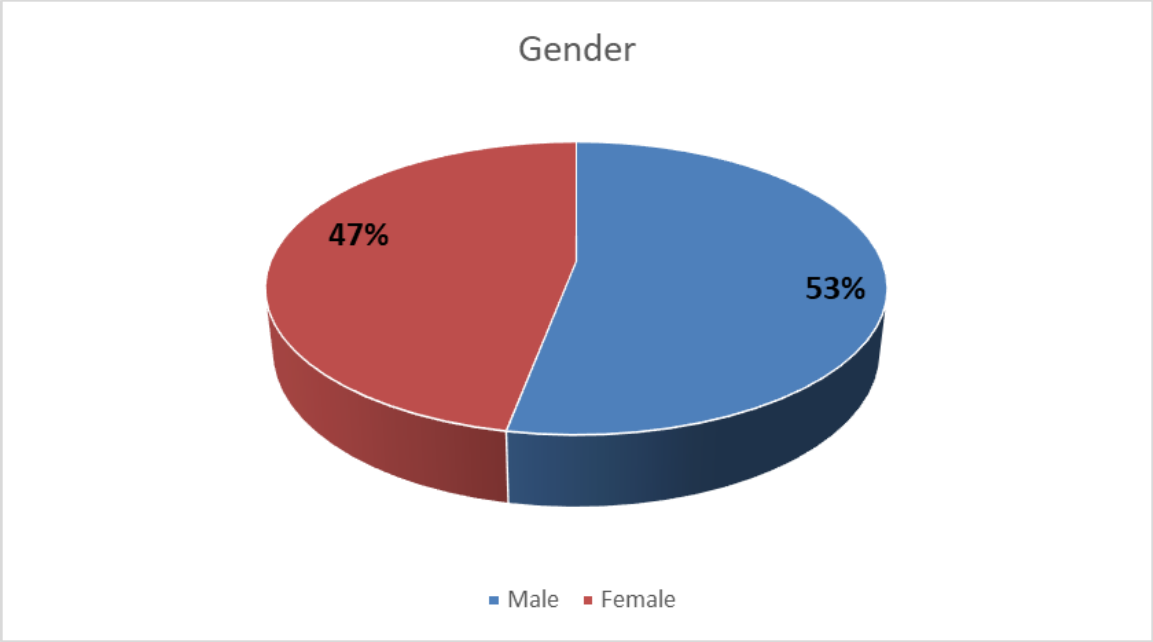


Figure 9 Characteristics of Respondents based on Gender

4.2.3. Characteristics Based on Education Stages

The classification of respondents based on education level shows that the majority hold a high school diploma (47%), followed by those with a bachelor's degree (18%), junior high school education (17%), elementary school education (12%), diploma education (8%), and respondents who did not complete school (0%). The distribution of respondents based on education stages is presented in Figure 10.

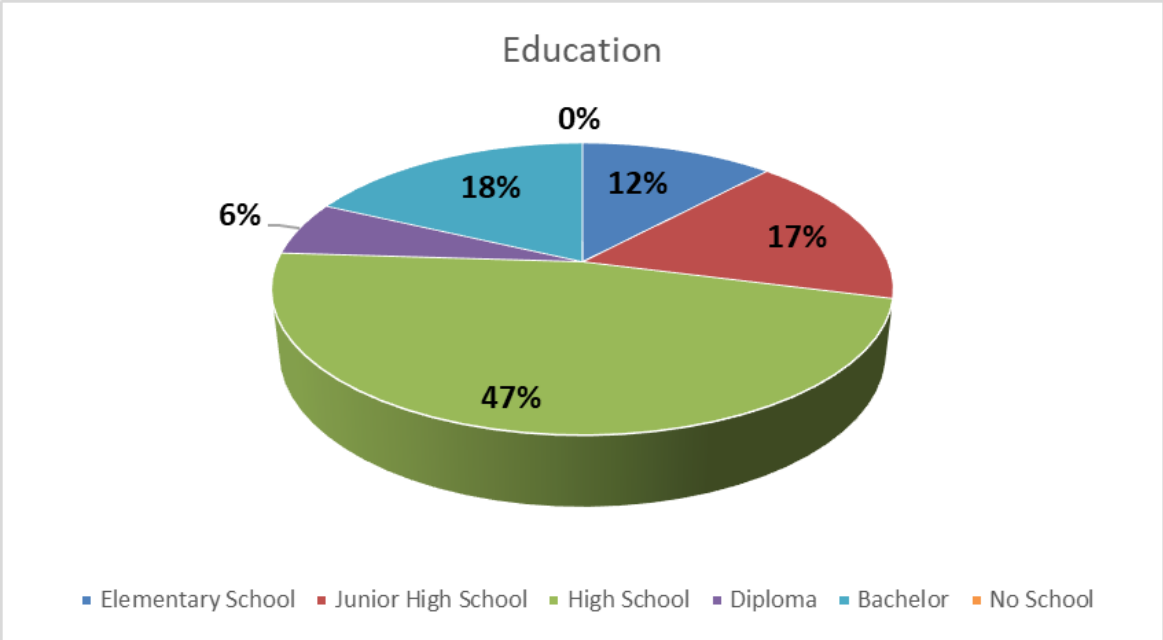


Figure 10 Characteristics of Respondents based on Education Stages

4.2.4. Characteristics Based on Occupation

The classification of respondents by occupation indicates that the dominant group consists of self-employed individuals or entrepreneurs (39%), followed by students (20%), civil servants/Indonesian National Armed Forces/Regional-Owned Enterprises employees (16%), housewives (14%), laborers/coolies/craftsmen (10%), farmers (1%), fishermen (0%), and those who are unemployed or not working (0%). The occupational distribution of respondents is shown in Figure 11.

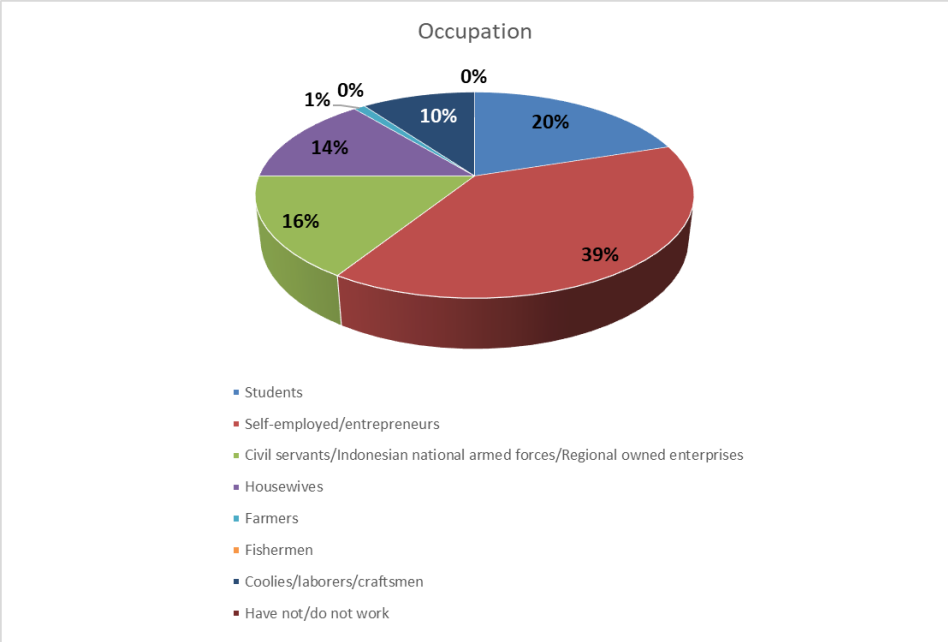


Figure 11 Characteristics of Respondents based on Occupation

4.2.5. Characteristics Based on Revenues

The most common income group among respondents is those earning more than 2 million IDR (36%), followed by those earning 1.5–2 million IDR (23%), 0.5–1 million IDR (15%), less than 0.5 million IDR (14%), and 1–1.5 million IDR (12%). The income distribution of respondents is illustrated in Figure 12.

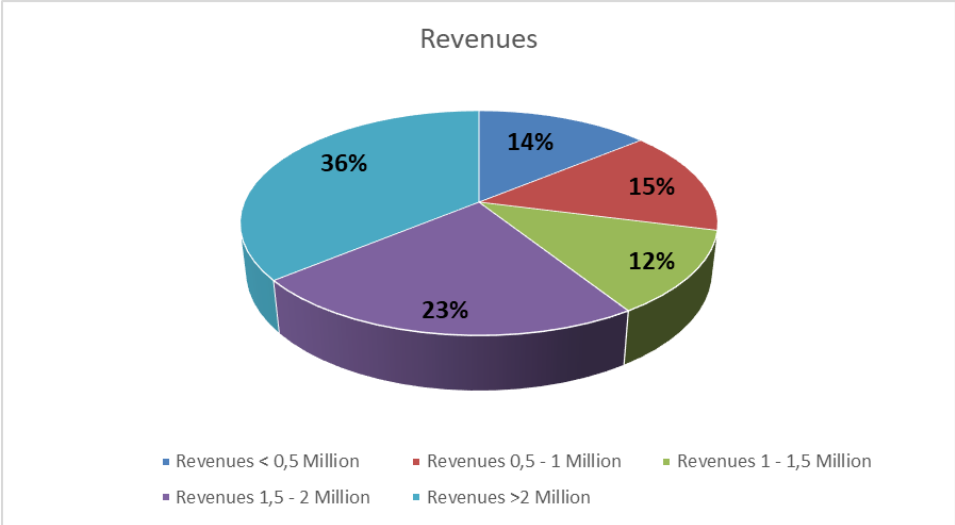


Figure 12 Characteristics of Respondents based on Revenues

4.2.6. Characteristics Based on Trip Purpose

The dominant trip purpose among respondents is work-related travel (36%), followed by other purposes (24%), returning home (23%), social activities (7%), recreation (6%), school (3%), and inter-passenger purposes (1%).

The distribution of respondents based on trip purpose is presented in Figure 13.

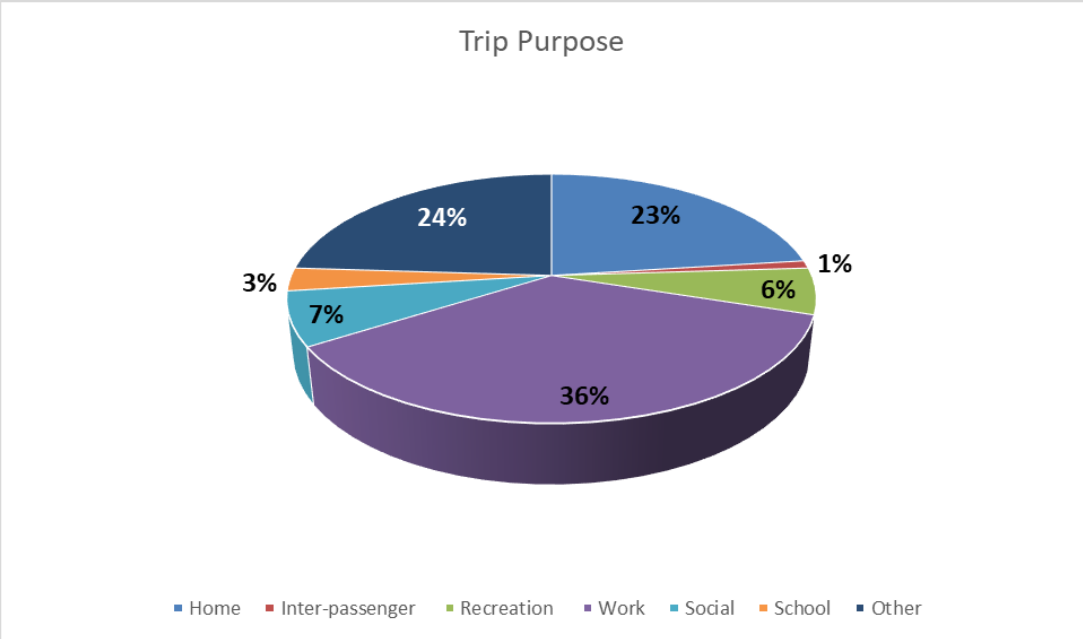


Figure 13 Characteristics of Respondents based on Trip Purpose

4.2.7. Characteristics Based on Mode of Transportation

The majority of respondents reported using motorcycles as their primary mode of transportation (93%), followed by cars (5%), walking (2%), and no reported use of bicycles or public transportation (0%).

The distribution of transportation modes used by respondents is shown in Figure 14.

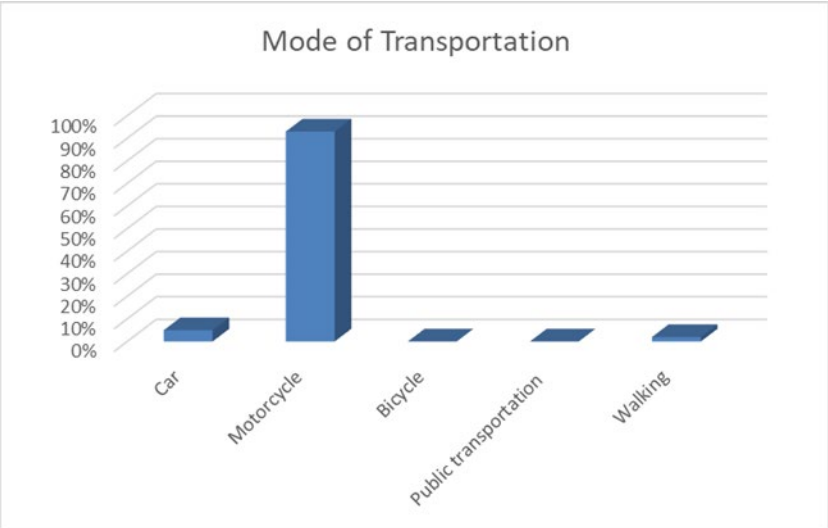


Figure 14 Characteristics of Respondents based on Mode of Transportation

4.3. Trip Distribution Analysis

This step aims to distribute the number of trips originating from each zone to other internal zones that serve as destinations. The results of this distribution are presented in Table 2 below.

Table 2 Origin-destination Matrix with Intrazonal Trips

Zone	Villages	Sungai Alam	Air Putih	Senggoro	Rimba Sekampung	Bengkalis Kota	Damon	Kelapapati	Wonosari	Kuala Alam	Bantan Tua	Teluk Latak	Meskom	**Total**
1	Sungai Alam	2	1	1	0	0	0	1	1	0	0	0	0	**6**
2	Air Putih	2	2	3	0	1	0	0	0	0	0	0	0	**8**
3	Senggoro	2	2	4	1	2	1	2	0	1	1	0	0	**16**
4	Rimba Sekampung	0	1	1	2	3	1	1	1	0	0	1	0	**11**
5	Bengkalis Kota	2	0	3	0	2	1	2	1	0	0	0	1	**12**
6	Damon	1	3	1	0	1	4	0	0	0	0	0	1	**11**
7	Kelapapati	0	2	1	1	3	3	7	0	0	0	0	0	**17**
8	Wonosari	0	1	3	2	2	2	5	4	0	0	0	0	**19**
9	Kuala Alam	0	0	0	0	0	0	0	0	0	0	0	0	**0**
10	Bantan Tua	0	0	0	0	0	0	0	0	0	0	0	0	**0**
11	Teluk Latak	0	0	0	0	0	0	0	0	0	0	0	0	**0**
12	Meskom	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Total	**9**	**12**	**17**	**6**	**14**	**12**	**18**	**7**	**1**	**1**	**1**	**2**	**100**

Zones 1 to 8 represent internal zones, while zones 9 to 12 are categorized as intermediate zones. Based on the origin-destination matrix table, including intrazonal trips, it can be observed that the highest number of trips is directed toward Zone 7, Kelapapati Village, with 18 trips.

Table 3 Origin-destination Matrix without Intrazonal Trips

Zone	Villages	Sungai Alam	Air Putih	Senggoro	Rimba Sekampung	Bengkalis Kota	Damon	Kelapapati	Wonosari	Kuala Alam	Bantan Tua	Teluk Latak	Meskom	**Total**
1	Sungai Alam	0	1	1	0	0	0	1	1	0	0	0	0	**4**
2	Air Putih	2	0	3	0	1	0	0	0	0	0	0	0	**6**
3	Senggoro	2	2	0	1	2	1	2	0	1	1	0	0	**12**
4	Rimba Sekampung	0	1	1	0	3	1	1	1	0	0	1	0	**9**

Zone	Villages	Sungai Alam	Air Putih	Senggoro	Rimba Sekampung	Bengkalis Kota	Damon	Kelapapati	Wonosari	Kuala Alam	Bantan Tua	Teluk Latak	Meskom	**Total**
5	Bengkalis Kota	2	0	3	0	0	1	2	1	0	0	0	1	**10**
6	Damon	1	3	1	0	1	0	0	0	0	0	0	1	**7**
7	Kelapapati	0	2	1	1	3	3	0	0	0	0	0	0	**10**
8	Wonosari	0	1	3	2	2	2	5	0	0	0	0	0	**15**
9	Kuala Alam	0	0	0	0	0	0	0	0	0	0	0	0	**0**
10	Bantan Tua	0	0	0	0	0	0	0	0	0	0	0	0	**0**
11	Teluk Latak	0	0	0	0	0	0	0	0	0	0	0	0	**0**
12	Meskom	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Total	**7**	**10**	**13**	**4**	**12**	**8**	**11**	**3**	**1**	**1**	**1**	**2**	**73**

In Table 3, intra-zone trips are not included in the calculation. The table shows that the highest number of trips is toward Zone 3, corresponding to Senggoro Village.

From the travel table, the total number of population trips—or trips representing the entire population of travelers—can be estimated by multiplying the number of trips in each zone by the expansion factor. The expansion factor projects the sample data to the overall population to make the resulting values comparable to real-world conditions. The formula for calculating the expansion factor is presented below.

$$\text{expansion} = \frac{A}{B}$$

Description:
A = zone population

B = sample obtained

Table 4 Expansion Factor of Each Zone

Zone	Villages	Population	Percentage of Population per Zone (%)	Sample	Expansion Factor
1	Sungai Alam	2866	5,81%	6	493,64
2	Air Putih	4161	8,43%	8	493,64
3	Senggoro	7607	15,41%	16	493,64
4	Rimba Sekampung	5399	10,94%	11	493,64
5	Bengkalis Kota	5835	11,82%	12	493,64
6	Damon	5381	10,90%	11	493,64
7	Kelapapati	8567	17,35%	17	493,64
8	Wonosari	9548	19,34%	19	493,64
	Total	**49364**	**100%**	**100**	

After calculating the expansion factor for each zone, this factor is then used to convert the sample-based trip data into population-based estimates. Each trip demand value is multiplied by the corresponding expansion factor in its zone, resulting in the estimated trip demand for the full

population. Table 4 presents the expansion factor for each zone, which serves as the basis for scaling up the sample data to match the total population.

Subsequently, an origin-destination matrix representing population-level trips, including intrazonal movements, is generated. This matrix is presented in Table 5, which displays the estimated number of trips between zones after applying the expansion factors.

Table 5 Origin-destination Matrix in the Form of Population Data with Intrazonal Trips

Zone	Villages	Sungai Alam	Air Putih	Senggoro	Rimba Sekampung	Bengkalis Kota	Damon	Kelapapati	Wonosari	**Total**
1	Sungai Alam	987	494	494	0	0	0	494	494	**2962**
2	Air Putih	987	987	1481	0	494	0	0	0	**3949**
3	Senggoro	987	987	1975	494	987	494	987	0	**6911**
4	Rimba Sekampung	0	494	494	987	1481	494	494	494	**4936**
5	Bengkalis Kota	987	0	1481	0	987	494	987	494	**5430**
6	Damon	494	1481	494	0	494	1975	0	0	**4936**
7	Kelapapati	0	987	494	494	1481	1481	3455	0	**8392**
8	Wonosari	0	494	1481	987	987	987	2468	1975	**9379**
	Total	**4443**	**5924**	**8392**	**2962**	**6911**	**5924**	**8886**	**3455**	**46896**

Table 6 Origin-destination Matrix in the Form of Population Data without Intrazonal Trips

Zone	Villages	Sungai Alam	Air Putih	Senggoro	Rimba Sekampung	Bengkalis Kota	Damon	Kelapapati	Wonosari	**Total**
1	Sungai Alam	0	494	494	0	0	0	494	494	**1975**
2	Air Putih	987	0	1481	0	494	0	0	0	**2962**
3	Senggoro	987	987	0	494	987	494	987	0	**4936**
4	Rimba Sekampung	0	494	494	0	1481	494	494	494	**3949**
5	Bengkalis Kota	987	0	1481	0	0	494	987	494	**4443**
6	Damon	494	1481	494	0	494	0	0	0	**2962**
7	Kelapapati	0	987	494	494	1481	1481	0	0	**4936**
8	Wonosari	0	494	1481	987	987	987	2468	0	**7405**
	Total	**3455**	**4936**	**6417**	**1975**	**5924**	**3949**	**5430**	**1481**	**33568**

4.4. Route Planning

The public transportation route planning in Bengkalis City focuses on areas with the highest levels of travel demand. The proposed route begins in Sungai Alam Village, near the State Polytechnic of Bengkalis, and terminates in Kelapapati Village at RSUD Bengkalis. This corridor is selected because it includes a dense concentration of educational institutions, residential neighborhoods, and public facilities. Additionally, the city center, which functions as the economic and governmental hub, contains numerous shopping centers and office buildings. Based on the analysis of trip demand, two alternative routes have been proposed.

Alternative Route 1 begins at the State Polytechnic of Bengkalis and proceeds through the following streets: State Polytechnic of Bengkalis → Bathin Alam Street → Pramuka Street → Bantan Street → Lembaga Street → HR. Soebrantas Street → Antara Street → SD 04 Street → Kelapapati Darat Street → M. Tayib Street → Kelapapati Laut Street → Jend. Sudirman Street → Bengkalis Street

→ Panglima Minal Street → Awang Mahmuda Street → Bathin Alam Street → back to State Polytechnic of Bengkalis (see Figure 15).

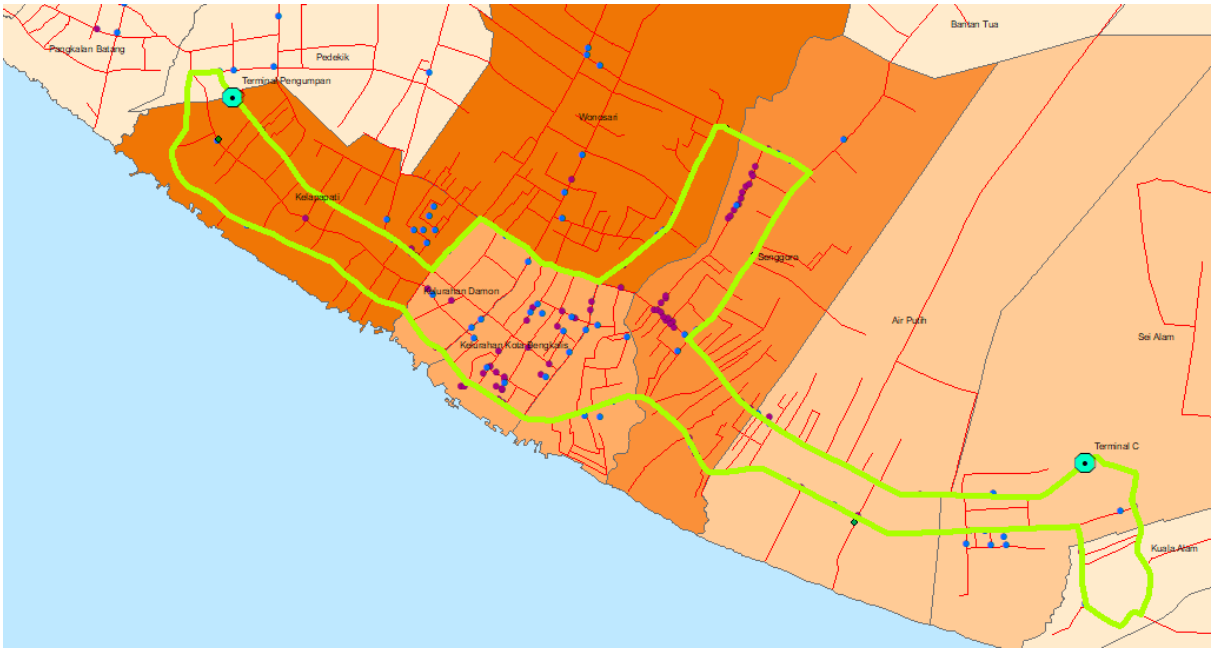


Figure 15 Alternative Route 1

Alternative Route 2 follows a slightly different alignment, also starting at the State Polytechnic of Bengkalis. It continues along Bathin Alam Street → Pramuka Street → Bantan Street → Lembaga Street → Baru Desa Wonosari Street → Wonosari Barat Street → SD 04 Street → Kelapapati Darat Street → M. Tayib Street → Kelapapati Tengah Street → Diponegoro Street → A. Yani Street → Jend. Sudirman Street → Bengkalis Street → Panglima Minal Street → Awang Mahmuda Street → Bathin Alam Street → back to State Polytechnic of Bengkalis (see Figure 16).

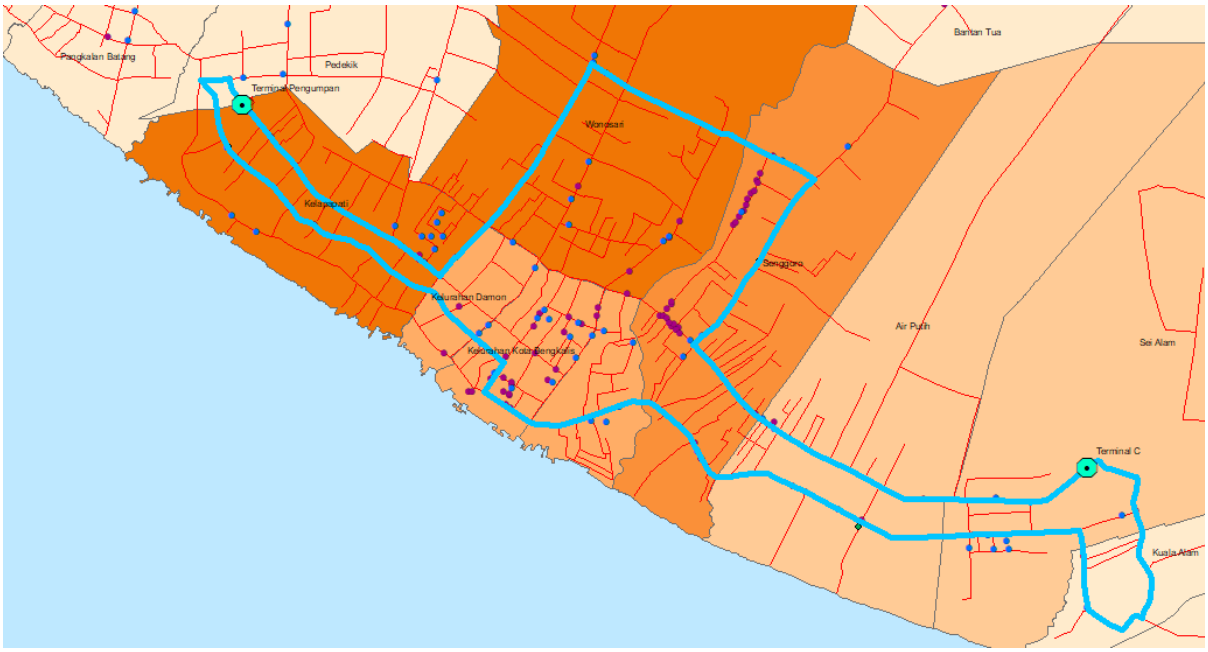


Figure 16 Alternative Route 2

4.5. Terminal and Bus Stop Planning

This plan proposes two terminal locations: the main terminal in the vicinity of the State Polytechnic of Bengkalis and the feeder terminal near the RSUD area. Bus stops will be installed along Alternative Route 1 and Route 2 to serve passengers at strategic points. The placement of bus stops along Alternative Route 1 is shown in the figure below. Furthermore, the complete layout of bus stops and terminal locations along the selected alternative route is shown in Figure 17.

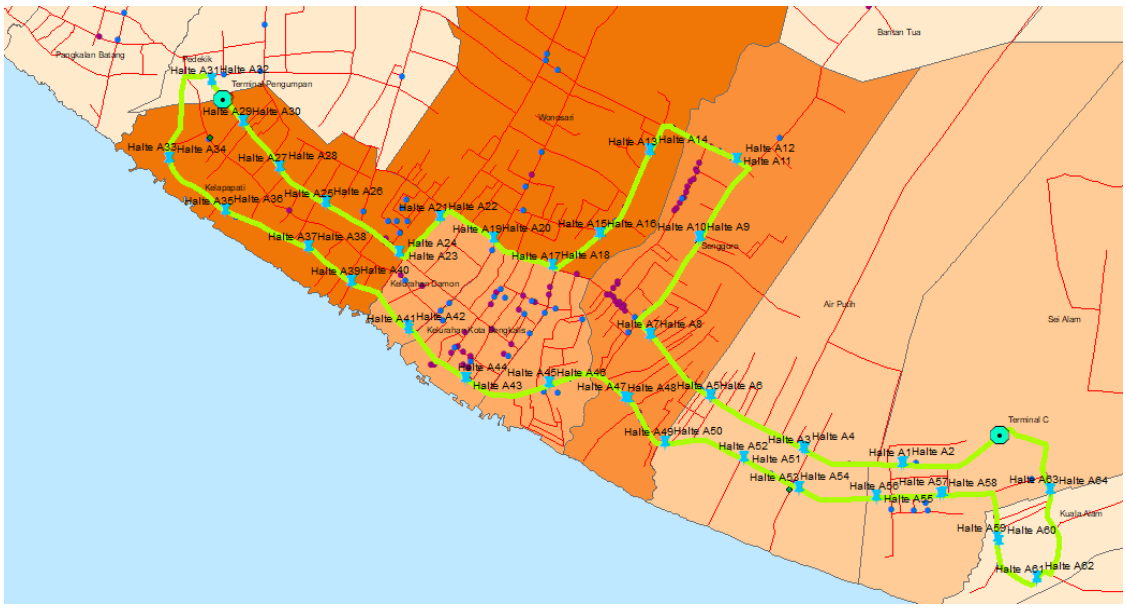


Figure 17 Bus stops and Terminals on Alternative Route 1

The locations of terminal points and bus stops are presented in Table 7 below.

Table 7 Points of the Location of Bus Stops and Terminals on Alternative Route 1

No	Bus Stops	Villages
1	Bus stop A1	Sungai Alam
2	Bus stop A2	Sungai Alam
3	Bus stop A3	Air Putih
4	Bus stop A4	Air Putih
5	Bus stop A5	Air Putih
6	Bus stop A6	Air Putih
7	Bus stop A7	Senggoro
8	Bus stop A8	Senggoro
9	Bus stop A9	Senggoro
10	Bus stop A10	Senggoro
11	Bus stop A11	Senggoro
12	Bus stop A12	Senggoro
13	Bus stop A13	Wonosari
14	Bus stop A14	Wonosari
15	Bus stop A15	Wonosari
16	Bus stop A16	Wonosari
17	Bus stop A17	Bengkalis Kota
18	Bus stop A18	Wonosari
19	Bus stop A19	Damon
20	Bus stop A20	Wonosari

No	Bus Stops	Villages
21	Bus stop A21	Damon
22	Bus stop A22	Kelapapati
23	Bus stop A23	Kelapapati
24	Bus stop A24	Kelapapati
25	Bus stop A25	Kelapapati
26	Bus stop A26	Kelapapati
27	Bus stop A27	Kelapapati
28	Bus stop A28	Kelapapati
29	Bus stop A29	Kelapapati
30	Bus stop A30	Kelapapati
31	Bus stop A31	Pedekik
32	Bus stop A32	Pedekik
33	Bus stop A33	Kelapapati
34	Bus stop A34	Kelapapati
35	Bus stop A35	Kelapapati
36	Bus stop A36	Kelapapati
37	Bus stop A37	Kelapapati
38	Bus stop A38	Kelapapati
39	Bus stop A39	Kelapapati
40	Bus stop A40	Kelapapati
41	Bus stop A41	Damon
42	Bus stop A42	Damon
43	Bus stop A43	Bengkalis Kota
44	Bus stop A44	Bengkalis Kota
45	Bus stop A45	Rimba Sekampung
46	Bus stop A46	Rimba Sekampung
47	Bus stop A47	Senggoro
48	Bus stop A48	Senggoro
49	Bus stop A49	Air Putih
50	Bus stop A50	Air Putih
51	Bus stop A51	Air Putih
52	Bus stop A52	Air Putih
53	Bus stop A53	Air Putih
54	Bus stop A54	Air Putih
55	Bus stop A55	Sungai Alam
56	Bus stop A56	Sungai Alam
57	Bus stop A57	Sungai Alam
58	Bus stop A58	Sungai Alam
59	Bus stop A59	Kuala Alam
60	Bus stop A60	Kuala Alam
61	Bus stop A61	Kuala Alam
62	Bus stop A62	Kuala Alam
63	Bus stop A63	Sungai Alam
64	Bus stop A64	Sungai Alam
65	Terminal C	Sungai Alam
66	Feeder terminal	Kelapapati

The locations of the bus stop points along Alternative Route 2 are shown in Figure 18 below.

Figure 18 Bus Stops and Terminals on Alternative Route 2

The locations of terminal points and bus stops are presented in Table 8 below.

Table 8 Points of the Location of Bus Stops and Terminals on Alternative Route 2

No	Bus Stop	Villages
1	Bus stop A1	Sungai Alam
2	Bus stop A2	Sungai Alam
3	Bus stop A3	Air Putih
4	Bus stop A4	Air Putih
5	Bus stop A5	Air Putih
6	Bus stop A6	Air Putih
7	Bus stop A7	Senggoro
8	Bus stop A8	Senggoro
9	Bus stop A9	Senggoro
10	Bus stop A10	Senggoro
11	Bus stop A11	Senggoro
12	Bus stop A12	Senggoro
13	Bus stop A21	Damon
14	Bus stop A22	Kelapapati
15	Bus stop A23	Kelapapati
16	Bus stop A24	Kelapapati
17	Bus stop A25	Kelapapati
18	Bus stop A26	Kelapapati
19	Bus stop A27	Kelapapati
20	Bus stop A28	Kelapapati
21	Bus stop A29	Kelapapati
22	Bus stop A30	Kelapapati
23	Bus stop A31	Pedekik
24	Bus stop A32	Pedekik

No	Bus Stop	Villages
25	Bus stop A43	Bengkalis Kota
26	Bus stop A44	Bengkalis Kota
27	Bus stop A45	Rimba Sekampung
28	Bus stop A46	Rimba Sekampung
29	Bus stop A47	Senggoro
30	Bus stop A48	Senggoro
31	Bus stop A49	Air Putih
32	Bus stop A50	Air Putih
33	Bus stop A51	Air Putih
34	Bus stop A52	Air Putih
35	Bus stop A53	Air Putih
36	Bus stop A54	Air Putih
37	Bus stop A55	Sungai Alam
38	Bus stop A56	Sungai Alam
39	Bus stop A57	Sungai Alam
40	Bus stop A58	Sungai Alam
41	Bus stop A59	Kuala Alam
42	Bus stop A60	Kuala Alam
43	Bus stop A61	Kuala Alam
44	Bus stop A62	Kuala Alam
45	Bus stop A63	Sungai Alam
46	Bus stop A64	Sungai Alam
47	Bus stop B1	Wonosari
48	Bus stop B2	Wonosari
49	Bus stop B3	Wonosari
50	Bus stop B4	Wonosari
51	Bus stop B5	Wonosari
52	Bus stop B6	Wonosari
53	Bus stop B7	Wonosari
54	Bus stop B8	Wonosari
55	Bus stop B9	Pedekik
56	Bus stop B10	Kelapapati
57	Bus stop B11	Kelapapati
58	Bus stop B12	Kelapapati
59	Bus stop B13	Kelapapati
60	Bus stop B14	Kelapapati
61	Bus stop B15	Kelapapati
62	Bus stop B16	Kelapapati
63	Bus stop B17	Kelapapati
64	Bus stop B18	Kelapapati
65	Bus stop B19	Damon
66	Bus stop B20	Damon
67	Bus stop B21	Bengkalis Kota
68	Bus stop B22	Bengkalis Kota
69	Terminal C	Sungai Alam
70	Feeder Terminal	Kelapapati

The visualization of the planned bus stop is shown in Figure 19 below.

Figure 19 3D View of Bus Stop

5. CONCLUSION

This study aimed to develop a trip route planning model using Geographic Information Systems (GIS) to improve public transportation accessibility in Bengkalis City. Based on the data processing and analysis, two public transportation route alternatives were generated. Alternative Route 1 primarily serves zones with high concentrations of offices, educational institutions, and commercial facilities, while Alternative Route 2 traverses predominantly residential areas with limited access to key public destinations.

After evaluating both routes using criteria such as travel demand distribution and road geometry, Alternative Route 1 was identified as the more appropriate option. It integrates a wider range of urban functions, including residential, governmental, educational, and commercial zones, and aligns more closely with observed mobility patterns, offering broader service coverage. These findings contribute to a spatially informed approach for enhancing transportation accessibility in Bengkalis City. The methodology applied in this study may serve as a useful reference for future transportation planning efforts in similar urban contexts.

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SUSTAINABLE PEDAGOGICAL SPACE: WATER RISK REDUCTION MANAGEMENT THROUGH PERMACULTURE PEDAGOGY

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ABSTRACT

This study explores a Permaculture design approach to promote water conservation and reduce water dependency, particularly in response to plastic pollution. Permaculture emphasizes water ethics, conservation principles, rainwater harvesting (via tanks, soil, land, and biomass), greywater reuse, and biological remediation techniques for water recycling and purification. The study applies a contextually adapted environmental pedagogy based on Permaculture for primary school students in North Sumatra, Indonesia, focusing on sustainable water conservation and plastic litter risk reduction. A case study method was employed, targeting schools that voluntarily participated. The approach highlights three commonly overlooked dimensions in environmental education: community connection, place-based authenticity, and experience-based learning. Engaging young learners in local environmental monitoring, management, and communication aligns with several Sustainable Development Goals (SDGs), including SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 14 (Life Below Water). Thematic analysis revealed five key outcomes related to eco-pedagogy and place-based learning: (1) developing critical thinking through connections between past and present marine conditions; (2) identifying the stages of plastic degradation; (3) fostering respect for aquatic life and awareness of plastic waste impacts; (4) understanding local waterway issues from ditches to rivers and cultivating environmental responsibility; and (5) recognizing socio-environmental linkages through reflective activities such as letter-writing to local authorities. Findings emphasize the value of involving young participants in environmental initiatives, particularly those addressing plastic pollution and sustainable resource management. The study also proposes practical pedagogical strategies rooted in Permaculture principles for students, families, schools, and local communities.

Keywords: Environmental education; Microplastic; Permaculture design approach; Water pollution; SDGs

1. INTRODUCTION

Light and heavily polluted water waste is increasingly discharged into the environment. One major source of this pollution is plastic litter.

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The mass production of plastic and its accumulation in nature have continued at an abnormal rate due to uncritical use, poor implementation of the 3R principles (reduce, reuse, recycle), and the decline of effective waste disposal sites. Conventional plastic waste creates serious environmental problems when left exposed to nature. These include serving as conduits for harmful chemicals and disrupting ecological systems (Rangel-Buitrago et al., 2022). Plastic pollution threatens aquatic ecosystems, where marine organisms easily ingest microplastics. Once ingested, plastic particles enter their bodies and transfer through the food web (Khalid et al., 2021).

Ingested plastic has been linked to fatalities in marine species such as sharks, whales, sea turtles, walruses, and seals. The presence of plastic in the food web (Wang et al., 2023), drinking water (Marsden et al., 2019), and even human blood (Leslie et al., 2022) highlights the risk that plastic pollution poses to both humans and nature (Li & Wu, 2019). Plastic waste degrades through physical, chemical, and biological processes such as heat, UV light, and microbial activity (Yousif & Haddad, 2013). Wilyalodia et al. (2023) reported higher levels of microplastics during the wet season compared to the dry season. Lambert et al. (2014) classified plastic particles into macroplastics (about 5 mm), mesoplastics (1–5 mm), microplastics (less than 1 mm and above 0.1 μm), and nanoplastics (below 0.1 μm). These particles can originate from primary sources such as daily care products (Praveena, Shaifuddin & Akizuki, 2018) or secondary sources such as single-use plastics, fishing nets, and textiles (Kabir et al., 2021).

Due to their broad utility, plastic waste and its degraded forms have become omnipresent in rivers, oceans, soil, air, and even glaciers. With annual industrial plastic production estimated at around 300 million metric tonnes, roughly 8.3 billion tonnes of plastic have been produced since the 1950s (Jain, Singh & Susan, 2021). Many Southeast Asian countries are among the primary contributors to marine pollution (Meijer, 2021). Addressing plastic pollution requires global cooperation and the application of circular principles in waste management, such as prevention, reduction, reuse, recycling, and upgrading through the Permaculture design approach. According to Mathis et al. (2022), plastic litter risk reduction demands urgent responses from citizens, scientists, legislators, and collaborative networks.

Tun et al. (2020) found that while Indonesia has moderate policy development, market cooperation, and financial resources for plastic waste management, it lags in stakeholder engagement, public awareness, technological support, and research capacity. The highest performance was only noted in information dissemination. Given these limitations, efforts to improve public knowledge and awareness are essential. In this study, the first author addresses the gap in knowledge and awareness by offering a case study on applying Permaculture pedagogy to water risk reduction management among primary school students. The objective is to explore how Permaculture education can serve as a tool for raising awareness and promoting sustainable water and waste management practices at an early age. This approach aims to contribute to long-term improvements in public environmental awareness and sustainable waste management strategies.

2. LITERATURE STUDY

2.1. Water Permaculture

This study applies a Permaculture-based approach. As illustrated in Figure 1, bibliometric mapping shows a close association between “Permaculture” and “sustainability,” highlighting its relevance to environmental resilience. Permaculture emphasizes ethical principles: care for the earth, care for people, and care for future generations. It supports a self-sustaining system that transforms waste into resources through a closed-loop process (Jones, 2019). The approach

prioritizes waste reduction through a hierarchy that begins with rethinking, followed by refusing, reducing, reusing, repairing, and recycling. These principles contribute to water conservation efforts and help protect natural watercourses from pollution (Morrow, 2022).

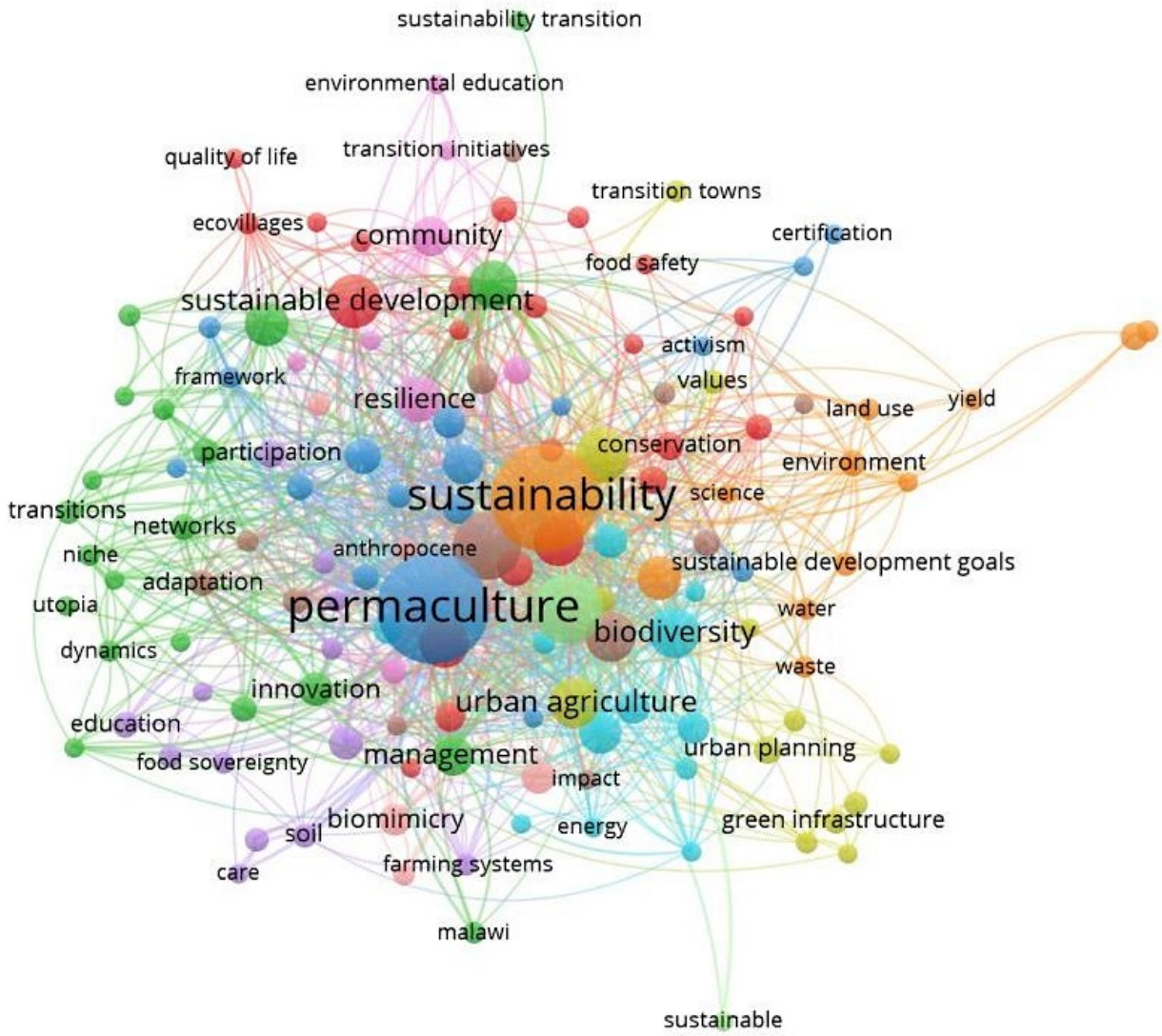

Figure 1. The bibliometric network of Permaculture systems based on Scopus (826 articles) and Web of Science (283 articles) search keywords of "Permaculture" with publication ranging from 1997-2024

Water contamination continues to increase due to a wide range of pollutants. At the same time, global demand for clean water rises while access becomes more limited (Liao, 2024). Local water sources should integrate with regional systems to reduce dependency and strengthen community access (Alam, Li, & Fida, 2024). Rooftop rainwater harvesting provides a feasible response to these challenges (Lepcha et al., 2024). Within this context, Permaculture supports water conservation using a set of guiding principles and techniques such as rainwater harvesting (through tanks, soil, land, and biomass), greywater reuse, recycling, and biological remediation.

Scholarly work on water harvesting through Permaculture is documented in several sources (e.g., Avis & Avis, 2018; Barnes, 2017; Bell, 2005; Bloom & Boehnlein, 2015; Elger, 2022; Falk, 2013; Fiebrig & Van De Wiel, 2021; Hemenway, 2009; Hoag, 2023; Holmgren, 2018; Morrow, 2022; Needham, 2021; Plantes, 2022; Rivett et al., 2018; Spillias, von Herzen & Holmgren, 2024; Whitefield, 2004). Morrow (2022) provides a detailed household model for Permaculture-based water use. Her approach follows six steps: in, store, use, reuse, store again, and clean. Rainwater

is first collected from a rooftop catchment, directed into ground-level tanks, and then flows into underground tanks and a pond. This water supports kitchen and laundry use. Water from baths and showers irrigates a greenhouse. Sink and washing machine water is diverted to gardens, while toilet waste flows to a septic tank. Wastewater from bathrooms and kitchens is processed through reedbeds, which filter nutrients and sediments before the water reaches a secondary pond and eventually an ephemeral creek. Biodegradable products are required for all greywater that enters the system. Hemenway (2009) notes that reedbeds are effective biological filters, while rock beds help oxygenate the water before it re-enters the ecosystem.

Water collected from rooftops must remain safe for human use. Achieving this goal depends on good design, maintenance, and appropriate materials. These include the roofing surface, pre-filtration units, gutters, tanks, pumps, and plumbing components (Li & Wu, 2019). Avis & Avis (2018) offer step-by-step instructions for building and managing such systems using Permaculture principles.

2.2. Permaculture Pedagogy

Natural ecosystems have a limited capacity to absorb pollutants and regenerate clean water. Plastic pollution, in particular, is connected with several Sustainable Development Goals (SDGs) related to education, public health, infrastructure, and ecological well-being. Human interaction with the environment must reflect ethical responsibility and long-term thinking (Morrow, 2022).

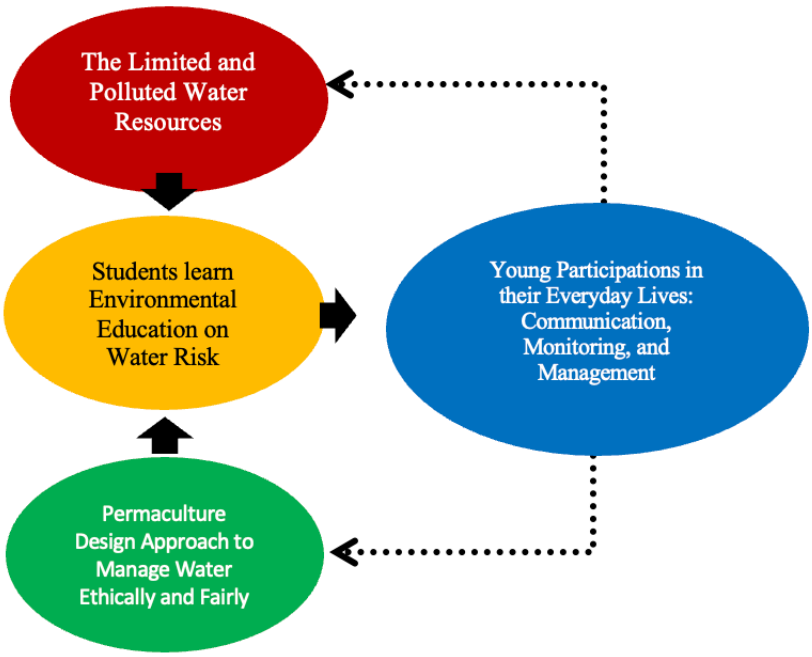

Figure 2. The framework of Permaculture Pedagogy, Environmental Education and Young Participations toward water risk reduction management

Several studies have demonstrated how Permaculture contributes to environmental education. These include teacher-to-teacher training (Conz, 2018), park-based instruction (Ozturk & Forsythe, 2024), outdoor classrooms in elementary schools (Shaojie et al., 2019), children's environmental camps (Stodulka, 2024), curriculum integration (Stodulka, 2020), environmental justice education (O'Riordan, 2014), and programs that link food systems with civic education (Williams, 2018).

This study applies a localized, culturally grounded Permaculture approach within primary schools in Indonesia. The model focuses on water conservation and plastic waste reduction. It addresses three neglected areas in environmental education: engagement with community, place-based

authenticity, and learning through experience (see Figure 2). These elements prepare students to participate in local environmental care efforts. Early engagement with these issues helps students build awareness, participate in observation and management, and communicate about their environment.

3. METHODS

This study adopts a qualitative case study approach grounded in the first author's teaching practice focused on environmental education related to plastic litter and water management. The intervention was conducted in 2022 across three public primary schools in North Sumatra, Indonesia: SD Negeri 102062, SD Negeri 163085, and SD Negeri 102071. The case study method was selected due to its capacity to explore complex educational phenomena, respond to context-specific "how" and "why" questions, and reveal the interconnections that shape participant experiences (Baxter & Jack, 2010).

The intervention involved students from grades 1 through 6, concentrating on integrating Permaculture-based waste management into classroom activities. Learning activities emphasized three pedagogical aspects: community engagement, place-based authenticity, and civics rooted in experiential learning (Kallio, 2020). These were aligned with a human–nature interdependence framework based on the ethics and design principles of Permaculture as articulated by Mollison et al. (1988).

Educational sessions were conducted by the first author and supported by classroom teachers. The sessions employed varied methods tailored to age and cognitive levels, including creative arts, role play, mini-projects, and problem-centered learning. These activities introduced the concepts of water conservation, plastic reduction, and sustainable practice through direct student involvement. Approval for the study was obtained from the Ministry of Education (MoE) offices in Serdang Bedagai and Dolok Masihul, North Sumatra. All participants were informed of the study's objectives and procedures. Written consent was obtained from school administrators, teachers, and the students' guardians. Ethical considerations guided the implementation of all activities, prioritizing the well-being and dignity of the student participants.

4. RESULTS AND DISCUSSION

The teaching of Permaculture design pedagogy on water risk reduction produced five themes that emerged as key outcomes within the context of eco-pedagogy and place-based learning: (1) the old and current sea, (2) plastic aging, (3) contaminated fish, (4) superman and superwoman actions, and (5) letter for the local government, to describe how limited natural resources, plastic pollution, and the SDGs are interconnected. These themes helped to shape the learning objectives of environmental care through the Permaculture design approach, which led to the active participation of young learners in ecological protection efforts, as summarized in Table 1.

Table 1. Teaching Permaculture Design Pedagogy on Water Risk Reduction

Themes	Environmental Issue and SDG link	Learning Objectives	Permaculture Strategy	Student Engagement
The old and current sea	Plastic waste in waterways leads to microplastic contamination in marine food chains. (SDG 3)	Compare past and present marine environments; understand the health impacts of polluted water.	Promote the reduction of plastic use and adoption of sustainable alternatives.	Monitoring: Identify polluted vs. clean water ecosystems. Management: Reflect on personal waste generation. Communication: Share awareness messages with peers.
Plastic ageing	Degradation of plastics into meso-, micro-, and nanoplastics threatens biodiversity. (SDG 14)	Understand plastic degradation stages over time.	Encourage the use of biodegradable alternatives and long-life products.	Monitoring: Recognize the persistence of plastic in marine environments. Management: Classify plastic by degradation timeline. Communication: Advocate for reduced plastic use.
Contaminated Fish	Microplastic ingestion by marine life risks food safety and health. (SDG 3)	Develop empathy for aquatic life and awareness of the impact of the food chain.	Promote biodegradable and eco-friendly consumption habits.	Monitoring: Observe how fish may ingest plastics. Management: Compare biodegradable vs. synthetic materials. Communication: Share the concept of a "plastic-free diet."
Environmental Superman and Superwoman Actions	Irresponsible waste disposal contributes to environmental degradation. (SDG 4)	Identify local waste problems and explore proactive solutions.	Promote environmental ethics and community clean-up responsibility.	Monitoring: Document areas with waste mismanagement. Management: Participate in cleaning public spaces. Communication: Make pledges for environmental care.
Letters to Local Government	Institutional gaps in innovation and waste policy hinder sustainability. (SDG 8; SDG 9)	Express environmental concerns and suggest solutions.	Encourage civic engagement and community-driven problem-solving.	Monitoring: Identify pressing local environmental issues. Management: Propose realistic solutions via role-play. Communication: Compose and send letters to authorities.

4.1. The Old Sea and Current Sea

In this activity, students explored the contrast between the historical richness of marine ecosystems and their present degradation due to plastic pollution. Traditionally, the ocean was a source of abundant and clean food. Today, it is increasingly contaminated by plastic waste, which is often ingested, intentionally or not, by marine life. These microplastics enter the food chain

and may ultimately reach humans, raising concerns for both food security and health (Fadare, 2020). This issue relates directly to SDG 3: Good Health and Well-being.

To initiate discussion, students were asked if they would eat a fish contaminated by microplastics. They unanimously responded, “no.” Follow-up questions explored whether fish can recognize microplastics as harmful, to which students again answered “no.” This prompted a conversation on the inability of marine animals to differentiate plastics from food and the consequences for ecosystem health.

A spontaneous incident added realism to the session. One student accidentally dropped a plastic bottle, which leaked and became unusable. This was a teachable moment, illustrating how fragile and waste-prone plastic products can be. The incident deepened the students’ understanding of plastic as a pollutant. Students were then asked to depict their interpretations of the “old sea” and the “current sea” using two blank sheets of paper. The “old sea” was filled with vibrant marine life, while the “current sea” featured plastic debris and microplastic particles (Figure 3). Students worked in small groups, with each member assigned a task: drawing, coloring fish, cutting out waste pieces, and assembling the scenes.

Figure 3. Students drew the old and current sea

The old sea was illustrated with many fish, while the current sea was illustrated with plastic waste and microplastics. The students were divided into groups to allow collaboration. Each member had a role. One student drew the old sea; another drew the current sea; the third coloured fish printed for them, and the last cut out waste pieces to represent the current sea. The students understood the tasks easily. They worked cooperatively, as shown in the figures. Some

students shared words expressing their concerns about the polluted sea with their classmates and uploaded them to social media, as seen in Figure 4 below.

Figure 4. Students shared what they drew and gave notes on taking care of our current sea in front of the classroom

At the end of the class, the students performed a short fictional role-play as a family eating fish together. They prepared simple equipment for the scene, including plates, fish ornaments, and pieces of paper to represent rice. After a while, during the meal, they acted out vomiting and

stomach-ache as a result of high microplastic contamination. This activity is illustrated in Figure 5 below [Primary School at SD Negeri 102062, Grade 4].

Figure 5. Students played on a role how they were contaminated by microplastic fish.

4.2. Plastic Aging

This learning activity focused on introducing students to the life cycle of plastic materials and how they deteriorate over time into smaller particles. Students were guided to understand the process of plastic degradation by examining four categories: macroplastics, mesoplastics, microplastics, and nanoplastics. These distinctions were based on the approximate time it takes for each stage to develop: 1 year, 10 years, 30 years, and 60 years, respectively.

To visualize this process, students began by coloring pictures of fish and cutting out small plastic pieces to simulate microplastics. They then affixed these pieces to display boxes labeled with time intervals to represent each stage of plastic breakdown. Plastic that remains whole after a year is considered macroplastic. After a decade, visible fragmentation occurs, producing mesoplastics. By the 30-year mark, plastic further breaks down into microplastics. After 60 years, only microscopic nanoplastics remain.

This activity reinforced the concept that plastics persist in ecosystems for decades, posing a significant threat to aquatic biodiversity and environmental health, an issue aligned with SDG 14: Life Below Water. Students were encouraged to reflect on the longevity of plastic materials and the importance of using environmentally sustainable alternatives. Figure 6 illustrates the students' creative work as they presented their plastic aging models. The hands-on approach allowed students to grasp everyday plastic consumption's invisible yet lasting impacts.

Figure 6. The students showed their plastic aging arts.

4.3. Contaminated Fish

This activity introduced students to the pervasive nature of plastic pollution and its ecological implications. The session began with a discussion on common single-use plastic items, such as plastic bags, Styrofoam containers, and disposable utensils, and how these materials often enter waterways. The students learned that conventional plastics contain harmful chemicals and degrade much more slowly than natural materials.

To build understanding, the students were asked a series of comparative questions: Which decomposes more easily in nature, (1) a dead animal or plastic, (2) plants or plastic, (3) wood or plastic, (4) vegetables or plastic, (5) fruit or plastic, (6) seashells or plastic, and (7) the human body or plastic? Most students correctly identified that natural materials decompose more readily. This led to a conversation about the durability of plastic and the need to consider environmentally safer alternatives.

To reinforce the lesson, students participated in hands-on and role-play activities. First, they drew and coloured fish (Figure 7) and each student expressed their creative interpretation. Then, in small groups, they enacted a role-play in which some students represented fish and others represented plastic litter in the ocean. The “fish” characters, acting out hunger, approached what appeared to be food, pieces of plastic, and “ate” them. They then mimed symptoms such as stomach pain, illustrating the consequences of ingesting plastic waste.

Figure 7. The students drew their own fish for role-play activities

Through this performance, students became more aware of how microplastic contamination affects marine life and the broader food chain. The activity underscored connections to SDG 3: Good Health and Well-being and SDG 14: Life Below Water. After the performance, students encouraged one another to avoid plastic use and promoted the use of eco-friendly alternatives.

The role-plays concluded with student-led messages calling for reduced plastic consumption. In one class, students recorded short messages and presented handmade signs urging their peers and families to reduce plastic usage. They affirmed these ideas through collaborative discussions and symbolic actions (Figure 8).

Figure 8. The students performed their role-play. They were illustrated to be fish and plastic waste in the sea (Primary School at SD Negeri 102071, Grade 1)

4.4. Environmental Superman and Superwoman Actions

The lack of participation from stakeholders and the broader society in environmental conservation has led to the careless disposal of large amounts of waste in local communities and natural areas, including nearby waterways such as ditches. SDG 4: Quality Education highlights that access to

education can improve quality of life and encourage people to take responsibility for respecting the environment. In this context, students were made aware of the importance of keeping nearby ditches clean to prevent litter from flowing into larger water bodies.

In this learning opportunity, the students wanted to be part of the solution. They were willing to help clean their school environment. Before doing so, the teacher encouraged them to act bravely like environmental Superman and Superwoman figures, taking the initiative to reduce plastic waste on their school grounds. As part of the activity, they created environmental crowns symbolizing Superman and Superwoman, as shown in Figure 9 below.

Figure 9. The students were ready to pick up waste in their school's ditch

The students were divided into three groups to clean designated areas: (1) the school's ditch, (2) the road next to the school, and (3) the ditch near shops around the school. At first, they felt uncomfortable, disgusted, and a bit afraid, as insects and worms might be among the waste. However, some of their friends encouraged them and showed that it would be manageable. The task was challenging because there were so many plastic items, and each group had only a few members, making cleaning difficult. Their plastic collection bags were full, but much waste remained, as shown in Figure 10.

Figure 10. The students filled their bags with plastic waste from their school's ditch

The students were asked, "Who did this?" They answered, "People." The first author also asked whether they felt shy about picking up the trash. They said, "No." Gradually, most of the supermen and superwomen became eager to collect waste from the ditch, and they kept filling their plastic bags as if it would never end. Afterward, they cleaned their hands before returning to the classroom.

From this activity, the students promised the Earth not to throw rubbish carelessly into ditches and onto roads. They wrote this promise on a piece of paper featuring a picture of the map of

Indonesia, and they pressed yellow fingerprints onto it as a symbol of their covenant with the universe, as shown in Figure 11 below.

Figure 11. the students made a covenant to take care of the universe

The students shared that they were happy and felt like useful people. At the same time, they also felt sad, angry, and uncomfortable when they saw a lot of plastic waste along the roadside and in the ditch [Primary School at SD Negeri 163085, Grade 3].

4.5. To Write a Letter to the Head of Region in Kabupaten Serdang Bedagai

All humankind, without exception, must take greater action and unplug the source of plastic litter. Students' participation can play a meaningful role in slowing it down at the local level, including by encouraging the local government to improve waste management and address social issues caused by environmental degradation.

The students were introduced to five major problems: lack of researchers, massive use of single-use plastics and non-biodegradable materials, limited recycling facilities, and the absence of strong green community movements. Alongside these, they also explored alternative solutions: (i) opening job opportunities for local researchers, (ii) opening job opportunities for producing cloth bags made from long-lasting materials (De Castro, 2021), (iii)opening job opportunities for developing plastic alternatives using organic and biodegradable materials. Green plastics can come from plant-based packaging (Baneshi et al., 2024), seaweed (Bose, Biswas & Roy, 2024), or fruit-based products that help reduce food loss (Leta, Adeyemi & Fawole, 2024); (iv) opening job opportunities for local recycling bin makers (Read, 1999); and (v) opening job opportunities for environmental event organizers (Roseland, 2000).

By opening up local job opportunities for youth in the region, it is possible to reduce unemployment, limit the use of plastic bags, and promote the production of eco-friendly products that support life and the environment. These ideas support Sustainable Development Goals such as SDG 8: Decent Work and Economic Growth and SDG 9: Industry, Innovation, and Infrastructure at the regional level.

The first step was for the students to read the letter script together. They were encouraged to understand its content, ask questions, and give suggestions. They also coloured the figures on the letter. After completing their letters, the students took photos with them, as seen in Figure 12 below. A short demonstration followed, where the children presented their letters.

Figure 12. The students took pictures with their letters before sending them to the head of the local government

Group 1 students acted as researchers and observed issues such as water pollution, air pollution from factories and transportation, and plastic litter. These researchers then reported their findings to the regent and proposed possible solutions. Group 2 students created T-shirt bags from used clothes as alternatives to plastic bags after watching a tutorial on making T-shirts without sewing. The students found the process simple and quick. They proudly displayed their handmade T-shirt bags and recorded a short video saying, “Plastic bags, no. T-shirt bags, yes.”

Group 3 students made plastic from organic materials by labeling their plastic items with images of natural sources. For example, they imagined plastic bottles made from watermelon and plastic bags made from apples, pears, sugarcane, and weeds. After labeling their plastic, they presented it to their classmates and said, “Organic plastic, yes. Non-biodegradable plastic, no.” Group 4 students illustrated themselves as recycling bin makers. They categorized the bins into recyclable, organic, and hazardous types. They also made a short video clip saying, “Recycle, yes.”

Group 5 students raised environmental awareness in their community by explaining the harmful impact of plastic and why it should be avoided. A few weeks after the lesson ended, the students' letter was successfully submitted to the head of the region in Kabupaten Serdang Bedagai, as shown in Figure 13 [Primary School at SD Negeri 102071, Grade 6].

It was found that the involvement of young participants in environmental actions holds significant importance, particularly in addressing nature's limited capacity, plastic pollution, and concerns related to the Sustainable Development Goals. Through this environmental education program, the students gained a meaningful space to explore the problem of plastic waste and its impact on water pollution in their local community. They learned about the causes and consequences of pollution affecting life below water. They also had opportunities to express their thoughts and feelings about the beauty of an unpolluted ocean and the discomfort caused by a polluted one through creative arts and hands-on activities.

The students’ voices were shared through presentations in front of their class, and they had the opportunity to write and deliver a letter to the head of the local government in Serdang Bedagai. Their messages reached various audiences, including classmates, local officials, and the broader community, who were directly and indirectly influenced by the students’ actions, communication, and experiences.

Figure 13. The students did demonstrations based on their topic, and the first author successfully submitted the students' letters to the head of the local government.

4.6. Practical Implications

Our Earth is choking with plastic litter. It is time to confront plastic pollution collectively through reducing, reusing, recycling, and reorienting. This study presents methodological insights based on the 12 Permaculture principles for students, their families, schools, and local communities, as shown in Table 2 below. These efforts are expected to strengthen water awareness and support its implementation (Fitriyani et al., 2024).

Table 2. Permaculture Principles on water risk reduction from plastic pollution

Permaculture Principles	Applications for Water Risk Reduction
Observe and interact (Permaculture Principle 1)	• Observe green and non-green materials • Observe what products or materials you can use repeatedly and safely • Observe whether the product is recycled or recyclable before buying
Catch and store energy (Permaculture Principle 2)	• Commit to using greener materials for long-term benefits and avoiding hazardous environmental substances, especially in water. • Provide a space for reuse and recycle storage material at home for later usage
The principle of harvest (Permaculture Principle 3)	• Reuse to conserve resources and reduce costs • Support circular economies through job creation and sustainable access to good
Self-regulate and accept feedback (Permaculture Principle 4)	• Brainstorm all the needs, wants, addictions, abilities, liabilities, and responsibilities to prevent and reduce material consumption • Practice responsible material use and maintenance • Evaluate recycling efforts in personal and community contexts
Use and value nature's gifts (Permaculture Principle 5)	• Discourage any use of a single product because this probably represents a devaluing of many of the potential uses for natural resources • Maximize the utility of natural resources through recycling
Make no waste (Permaculture Principle 6)	• Prioritize long-lasting, biodegradable materials • Support innovation that replaces toxic materials with sustainable alternatives
Design from pattern to details (Permaculture Principle 7)	• Audit household waste and identify avoidable items • Encourage donation and sharing economies to create beneficial relationship with people by building charitable areas for clothes, furniture, kitchen equipment, etc.

Permaculture Principles	Applications for Water Risk Reduction
Integrate, don't segregate (Permaculture Principle 8)	• Set a various technique of recycle strategies • Establish prevention programs on green products and services to boost the economy and save the environment • Share responsibility for recycling together in the community
Use a small and slow system (Permaculture Principle 9)	• Reuse second rather than buy new ones • Promote recycling methods that are simple to apply and maintain, small-scale, local resources
Use and value diversity (Permaculture Principle 10)	• Demand greener products and less packaging • Encourage reuse acts at all sustainable products to all ages, at all types of workplaces, at all interests, at all cultural contexts • Design and recycle diverse products between local and regional types
Mind the margins and look to the Edges (Permaculture Principle 11)	• Do awareness-raising campaigns to educate the public and encourage consumers to demand less waste goods and resource-efficient market • Donate reusable items to needy people • Create a recycling society project and start a repair cafe
Cultivate vision & respond to change (Permaculture Principle 12)	• Keep leag how to do better prevention acts through self-education (books, social media, AI learning, etc.) • Start a tool library in the community for innovative reuse movements • Educate locals to separate waste by type through the recycling education program

Source: adapted from Holmgren (2018) and Morrow (2022)

5. CONCLUSION

Climate change and environmental degradation continue to challenge global and local sustainability. Education holds a key role in preparing young learners to respond constructively to the growing impact of plastic pollution. Permaculture design offers a practical and ethical model for reconnecting with natural systems and addressing environmental issues at the community level (Centemeri, 2019; Rhodes, 2018).

In this study, students showed increased awareness of marine vulnerability and the persistence of plastic waste in ecosystems. They engaged meaningfully in activities that strengthened their understanding of environmental care and aligned with Sustainable Development Goals (SDGs). Through context-specific learning, they reflected on their water consumption and its consequences for both human health and natural systems. The example of student-led actions demonstrates the potential of youth to influence their peers, families, and communities through responsible participation and environmental advocacy (Chawla & Cushing, 2007; Wallis & Loy, 2021).

Several limitations should be noted. The absence of a control group restricts the ability to identify whether changes resulted solely from Permaculture-based activities or other environmental education efforts in the school or community. The study did not apply quantitative methods, so it does not provide precise measurements of knowledge acquisition, attitude shifts, or behavioral outcomes.

Future research may benefit from combining qualitative and quantitative approaches across different schools and regions. Comparative studies could offer more insight into the effectiveness and adaptability of Permaculture-based education. Despite these limitations, the findings suggest that place-based environmental education has value in supporting local action. When repeated and shared in collective settings, small contributions hold promise for addressing plastic pollution through collaboration between schools, families, and local authorities.

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